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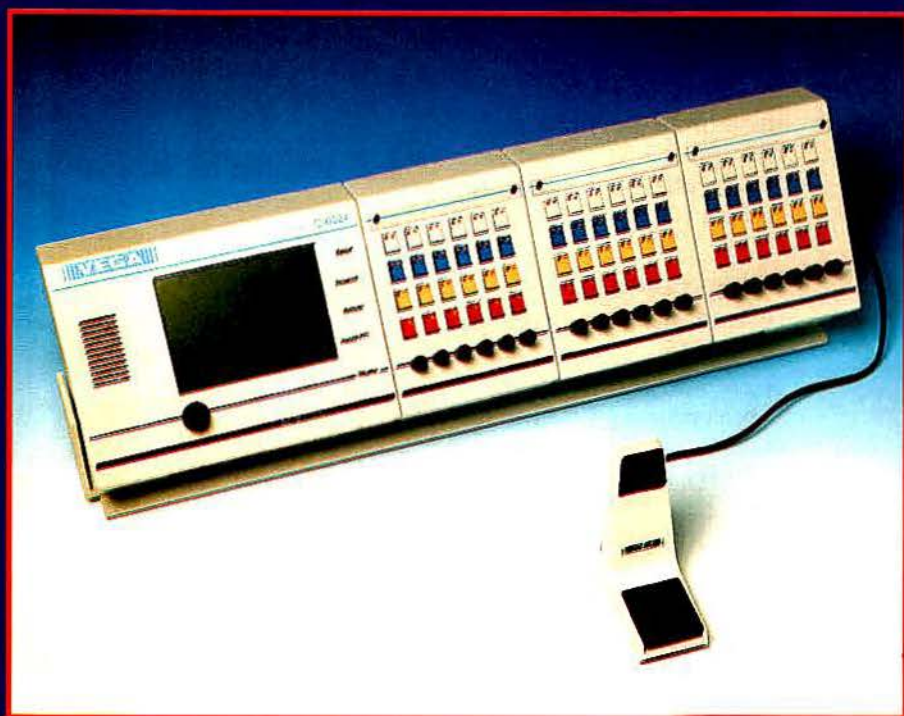
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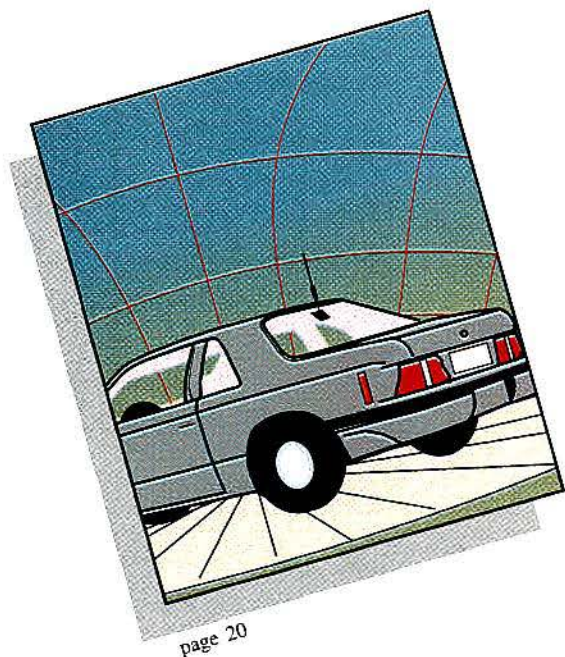
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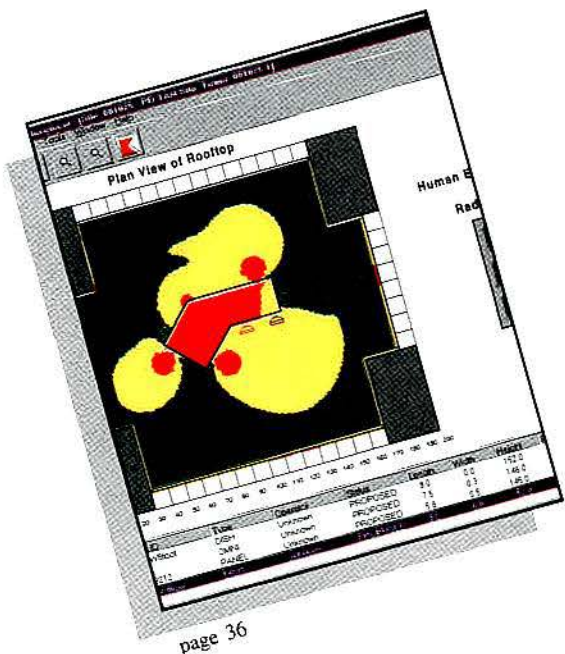
On the cover: It's *mobile*, it's *radio* and it's *technology*—albeit on another planet! The Mars mission uses data modems virtually identical to those for terrestrial applications. Story on page 56. Illustration courtesy of NASA and Dataradio.

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Beseeching for antenna sites, and a new partner for private radio?



Gimme antenna sites

The FCC chairman was sent a letter on July 11, assigning to the commission partial blame for construction delays primarily affecting personal communications service (PCS) telephone and paging (and, to a certain extent, cellular telephone, commercial mobile service and private radio [private wireless]). Certainly, PCS construction is the overwhelming motivation.

Thomas E. Wheeler, president of the Cellular Telecommunications Industry Association (CTIA), sent the letter to Reed Hundt, complaining about local governments that block antenna site development by declaring a moratorium on considering any such development. You see, courts may rule that regulations adopted by local governments are too restrictive and may roll them back. When they do, development moves ahead. But some courts have ruled that adopting no regulations and blocking all development with a moratorium is okay. Guess which method the local governments like to use?

A June 30 CTIA report cites 226 moratoria in effect as of that date, an increase of 11% since May and a 34% increase since April. CTIA wants the FCC to preempt moratorium regulations imposed by state and local governments, which might allow PCS antenna site development to proceed. Actually, the result might be a backlash on the part of the local governments. They tend to resist federal power unless it means Washington is buying something for them with the U.S. Treasury checkbook. So, there's your answer. Couple the preemption with a subsidy of, say, \$1 million to \$10 million per site, and maybe the locals will cooperate.

If little antennas at everyone's house were required to make PCS work, maybe preemption would have a better chance.

The FCC responds to overwhelming numbers, such as the millions of people who want to use direct satellite service to receive TV programs. For them, the agency preempted local regulation that prohibited small, dish-shaped antennas from being mounted on residences.

Maybe millions of people will use PCS phones and pagers, but they don't have to have antennas on their houses. In fact, many of them are convinced that they don't like the towers that make the phones—which they do like—work. So it's up to the carriers to get around the problem of local regulation, and in some cases, their customers.

"We beseech you to act immediately to deliver on the commission's oft-stated promise of new wireless competition and services by acting on CTIA's petition," the letter reads. Translation: "You and every commissioner except Susan Ness are about to leave office. Our members are bleeding big bucks. What have you got to lose? Help us out."

Good luck.

* * *

What about private radio?

Lots of people want part of the 60MHz of radio spectrum from 746MHz to 806MHz (channels 60–69) currently allocated for TV broadcasting.

Two groups that have been frozen, waived and otherwise maneuvered out of spectrum access include business and industrial private radio users and small specialized mobile radio (SMR) system operators. Manufacturing, mining and agricultural companies use private radio, as do a variety of other industrial and commercial enterprises. SMR operators offer communications services to many of the same enterprises for a monthly fee.

Because of wheeling and dealing about digital television channels, the FCC is preparing the way for almost all TV stations eventually to exit channels 60–69. Thanks to strong advocacy and congressional backing, public safety agencies are virtually assured of being allocated 24MHz from the frequency band. Other private radio users and the small SMR operators aren't faring so well.

Hopes were raised on May 14 when Sen. John Breaux (D-LA) introduced legislation that specified the allocation of 12MHz of spectrum by the FCC for private radio use. Licenses for the spectrum were to be charged an efficiency-based lease fee. That was good. A senator had been persuaded by radio users and their trade associations that users are willing to

pay their way—a tax, if you will—for spectrum that is impractical for them to purchase at auction.

On June 17, the Senate Commerce Committee passed an amendment introduced by its chairman, Sen. John McCain (R-AZ) that eliminated the lease fee provision. Why did McCain kill the lease fees? Because they are "a tax on business passed on to and paid by consumers." Well, yes. *That was the point.* Those who are granted licenses at auction pass along the license cost to consumers. Those who would be granted licenses by application would pay lease fees and pass the cost to consumers. *What's the difference?* Geezzz.

It gets worse. Now, what group is poised to compete with cellular, PCS, paging, the large SMR operators, the small SMR operators and private radio for the spectrum?

Broadcasters.

Yep. Soon as they exit the frequency band, they may be back in it with new forms of broadcast services. Commissioner James Quello said as much. And who is exempt, so far, from auctions? Yep. Broadcasters.

The latest word is that service rules for the 36MHz that isn't earmarked for public safety will be flexible. The translation of "flexible" is "sold to the highest bidder, who can use it in almost any way." Flexible rules and auctions probably mean more cellular and PCS phone service and paging. It isn't practical for private radio users to bid for the large geographic coverage areas normally associated with auctions.

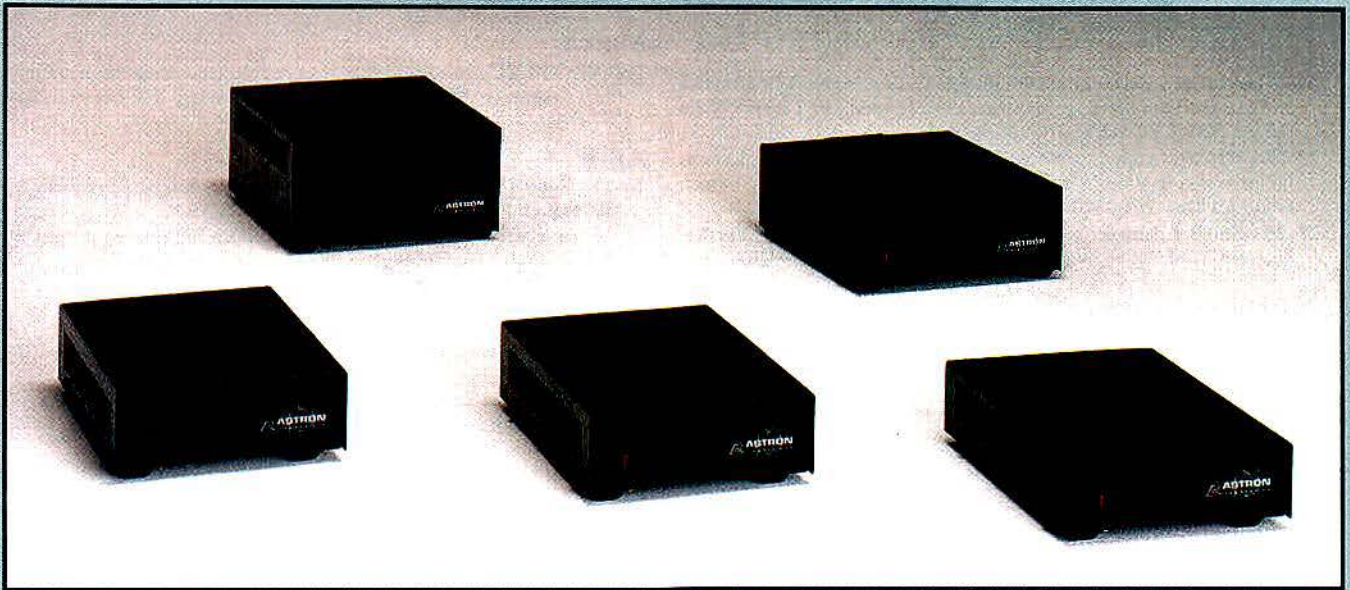
One alternative that has been discussed is to see what can be done to introduce legislation that would direct the National Telecommunications and Information Administration (NTIA) to share spectrum with private users. (The NTIA assigns spectrum used by federal government users; the FCC assigns the rest.)

Congress, you see, previously has passed legislation directing the NTIA to hand over spectrum to the FCC, an action that displaces a number of federal users. What that number is depends on who you ask. In this era of the FCC marking for auction any spectrum that isn't too difficult to wrest from current users, the NTIA might benefit from having more radio facilities in operation on its channels, as long as its new sharing partners are good neighbors.

Private radio seems to get its best results when its interests run in parallel with a bigger partner. Maybe NTIA can be such a partner.

—Don Bishop

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September

10-12—**Personal Communications Showcase**, sponsored by the Personal Communications Industry Association, Dallas Convention Center, Dallas. Contact: 800-326-8638.

October

6-8—**Industrial Telecommunications Association, Annual Conference and Membership Meeting**, ANA Hotel, Washington, DC. Contact: Karin Norton, 703-528-5115.

27-29—**Wireless Apps**, sponsored by the Cellular Telecommunications Industry Association, Seattle Convention Center, Seattle. Contact: Francesca Dea, 702-739-4025, or Tim Ayers, 202-736-3203.

27-28—**Small Business in Telecommunications Legislative Forum**, Sheraton Washington, Washington, DC. Contact: 202-736-3203.

November

6-7—**AMTEX**, sponsored by the American Mobile Telecommunications Association, Hilton at Walt Disney World Village, Orlando, FL. Contact: 202-331-7773.

6-8—**Second International Congress on Commercial Trunked Radio**, sponsored by the International Mobile Telecommunications Association, Hilton at Walt Disney World Village, Orlando, FL. Contact: 202-331-7773.

12-16—**Communications Marketing Conference**, sponsored by the Communications Marketing Association, Holiday Inn International Drive Resort, Orlando, FL. Contact: Bernie Brownson, 303-371-8182.

21—**Radio Club of America, Communications Symposium**, 88th Anniversary Dinner and Awards Presentation, New York Athletic Club, New York. Contact: Gerri Hopkins, 908-842-5070.

1998

February

23-25—**Wireless**, sponsored by the Cellular Telecommunications Industry Association, Georgia World Congress Center, Atlanta. Contact: 212-964-7000.

March

1-4—**ENTELEC**, sponsored by the Energy Telecommunications and Electrical Association, Marriott River Center, San Antonio, TX. Contact: 281-357-8700.

April

20-23—**Expo Comm/Comdex**, sponsored by E.J. Krause & Associates, McCormick Place, Chicago. Contact: 301-493-5500.

22-24—**International Wireless Communications Expo**, co-sponsored by *Mobile Radio Technology*, Las Vegas Convention Center, Las Vegas. Contact: 800-288-8606.

May

18-21—**Supercomm**, sponsored by USTA and TIA, Atlanta. Contact: 202-326-7300.

18-21—**Vehicular Technology Conference**, sponsored by IEEE Vehicular Technology Society, Westin Hotel, Ottawa, Canada. Contact: 908-562-3870.

June

20-22—**Canadian Wireless**, sponsored by the Canadian Wireless Telecommunications Association, Metro Toronto Convention Center, Toronto, Canada. Contact: 613-233-4888, ext. 102.

28-July 2—**UTC National Conference & Exhibition**, sponsored by UTC, The Telecommunications Association, Hynes Convention Center, Boston. Contact: 202-872-0030.



Mobile Radio Technology

Technical information for paging, SMR and private wireless networks

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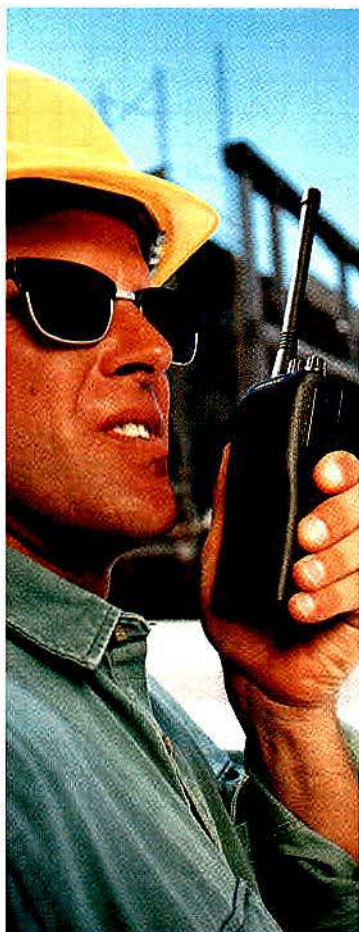
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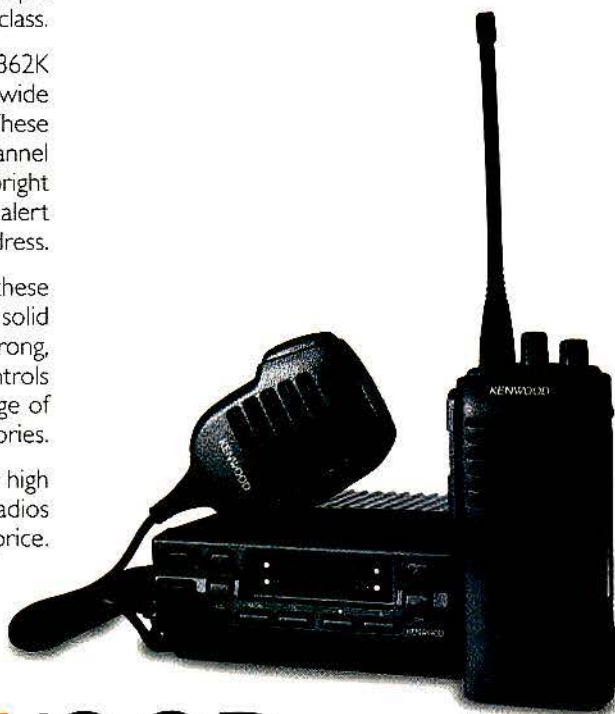
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The broadband noise generator: an alternative to sweep testing

By Harold Kinley, C.E.T.

In many routine uses, the broadband noise generator can be a viable alternative to hauling out the heavy old sweep generator and going through the hassle of interconnecting all the cables and setting up the system for a simple sweep test or alignment. The BNG-1000A broadband noise generator from Avcom, Richmond, VA, as shown in Photo 1 below, can, in many instances, greatly simplify sweep testing and alignment chores.

The unit is lightweight and portable—weighing in at just 2 pounds (0.9kg). The beauty of the instrument is its utter simplicity of operation and use. Aside from the on/off switch, the only operator control is the bypass switch that enables the operator to send the noise directly to the spectrum analyzer for a reference-level reading. The unit is powered by external power (+12Vdc to +24Vdc @ 200mA) through a coaxial dc power jack on the rear panel. A 115Vac to 12Vdc adapter is provided with the unit. The unit is designed to operate over a bandwidth from 3MHz to 1,000MHz. The output level is about -30dBm +3dB over the range.

Using the noise generator

As shown in Figure 1 below, there are only three cables to connect: from the BNG-1000A to the DUT (device under test), from the DUT back to the BNG-

1000A and from the BNG-1000A to the spectrum analyzer input. All connectors on the BNG-1000A are BNC, allowing quick and easy cable connections. Figure 2 at the right shows a spectrum analyzer display with no video filtering. This trace is obtained by switching the switch on the noise generator to the "bypass" or "direct path" mode. Notice how thick the noise appears on the spectrum analyzer display. To get a sharper image on the display, video filters on the spectrum analyzer can be activated. Figure 3 at the right shows a sharper image after the wideband video filter of the spectrum analyzer is switched in. Figure 4 at the right shows the best image using the narrowband video filter. Be aware that as filter bandwidth becomes more narrow, the sweep rate of the spectrum analyzer's timebase must be reduced. If the sweep rate is too high, the trace will become distorted. To get an accurate trace, the sweep rate must be correct for the frequency span, resolution bandwidth and type of video filter chosen. Many spectrum analyzers provide a warning indicator to signal the operator that the chosen sweep rate is too high for the frequency span, resolution bandwidth and video filter settings. Other analyzers prevent improper sweep rates by interlocking controls.

Typical displays

To check the frequency response of a quarterwave bandpass cavity, the setup shown in Figure 5 at the lower right is used. The typical response curve is shown in Figure 6 on page 59. The setup for a notch filter is the same as shown in Figure 5, along with the response curve in Figure 7 on page 59. Figure 8 shows the setup for checking the return loss on an

(continued on page 59)

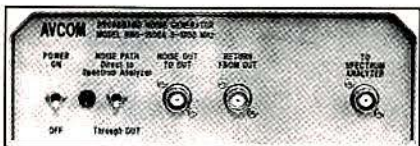


Photo 1. BNG-1000A broadband noise generator. Photo courtesy of Avcom of Virginia, Richmond, VA.

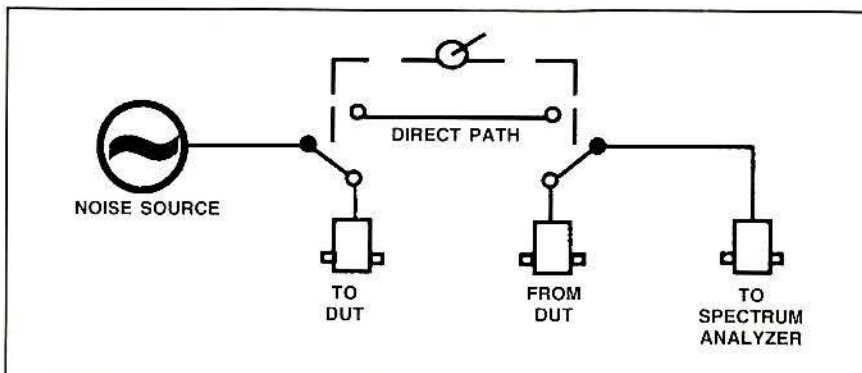


Figure 1. Block diagram of BNG-1000A broadband noise generator. Photo courtesy of Avcom of Virginia, Richmond, VA.

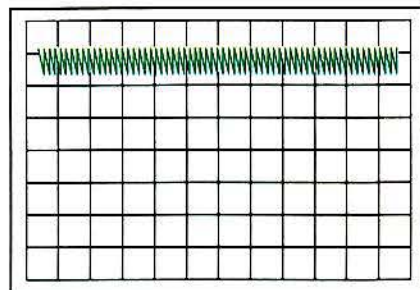


Figure 2. Trace without video filtering.

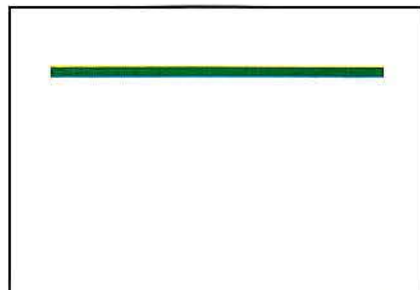


Figure 3. Trace with wideband video filter activated.

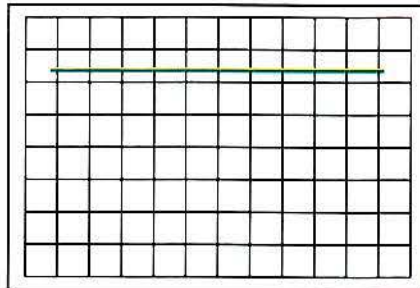


Figure 4. Trace with narrowband video filter activated.

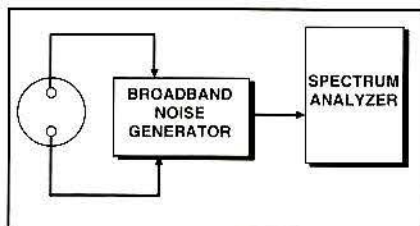


Figure 5. Test setup for checking response of quarterwave bandpass filter.

Kinley, a certified electronics technician, is regional communications manager, South Carolina Forestry Commission, Spartanburg, SC. He is a member of the Radio Club of America. He is the author of *Standard Radio Communications Manual: With Instrumentation and Testing Techniques*, which is available for direct purchase. Write to 204 Tanglewylde Drive, Spartanburg, SC 29301. Kinley's email address is hkinley@aol.com.



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Compressed voice data and targeted delivery for narrowband PCS paging

Compression of voice pages allows a greater number of them to be transmitted over the available RF bandwidth. Operators can place more subscribers into service by using targeted delivery techniques to maximize system resources.

By Dwight R. Smith

Voice paging has been around in previous forms for specialized applications. With the narrowband PCS that has become available from the 1996 PCS auctions, providers are able to commercialize voice paging for mass-market applications. This has been enabled by new technologies and delivery approaches that are being used in the paging industry.

The key technology that permits voice paging to occur is the two-way voice paging protocol within Motorola's family of wide-area paging protocols. The

protocol provides for two-way operation and voice message delivery.

Service concept

The simplest way to view voice paging is as an answering machine on a belt or in a purse. In normal operation, voice messages are delivered to the paging device and stored until the subscriber desires to listen to the message. After hearing the messages, subscribers have the option of saving or deleting the messages.

The obvious improvement to the answering machine paradigm is the wireless nature of the service; subscribers have near-immediate availability of the message. This solves the dilemma of access to the wireline answering machine that requires subscribers to periodically "call in" to check for messages. This change in delivery approach permits sub-

scribers to more promptly respond to their messages.

System architecture

The architecture of the voice paging infrastructure, as shown in Figure 1 below, looks similar to the traditional

The paging system architecture components referred to by common terms in this article are trademarked by Motorola under the following names:

Flex—the overall family of paging protocols, standing for flexible, asynchronous, wide-area paging protocol.

Inflexion—two-way voice paging protocol. Wireless Message Gateway (WMG) Terminal—paging entry service terminal.

RF-Conductor—paging system controller. RF-Orchestra—over-the-air paging transmitter. RF-Audience—over-the-air paging receiver. Tenor—voice pager.

Smith is principal staff engineer for Motorola's Paging Systems Group, Fort Worth, TX.

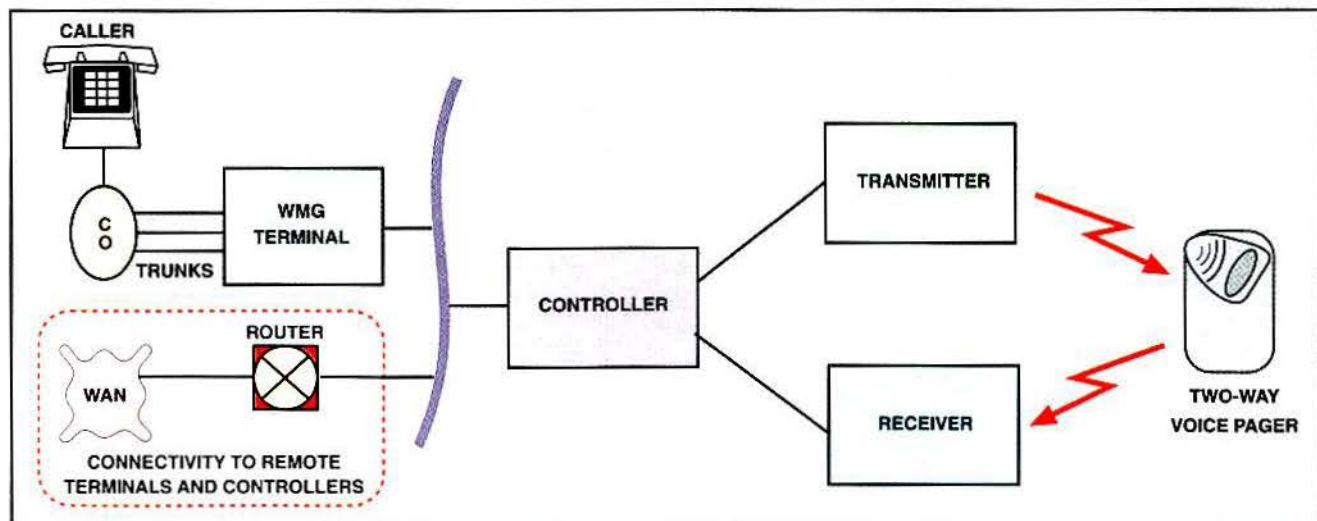


Figure 1. Wireless messaging system architecture for two-way voice paging.

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one-way paging system. However, there are differences. Support for the voice data imposes numerous loading and bandwidth demands on the system components. The page entry terminal used in one-way paging continues to do so with voice paging. However, the voice is collected, digitized, stored and used differently than messages for traditional one-way numeric or alphanumeric pages. In fact, the voice message is collected in a

manner comparable to wireline voice mail. However, the paging voice data compression factor plays a much greater role than in voice mail because of the multiple transmissions required for delivery.

The system controller handles the message delivery process. It formats and schedules control messages and then delivers the voice message using the appropriate transmission facilities. The paging

transmitter sends the message over the air to the pager. The paging receiver accepts the messages sent by the pager and sends them on the system controller. The

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Creating alphanumeric paging messages

As two-way voice paging develops, productivity tools for alphanumeric, multisite paging also continue to improve. Silverlake Communications, Calabasas, CA, has developed wireless PCS messaging software, under the name Airsource Business Suite, that is compatible with alphanumeric pager services and PCS providers supporting text messages to their devices. The program allows a network administrator to configure an email address, such as "PAGER," to send text to a pager through a wireless gateway. Alan Gould, director of business development for Silverlake, has compiled the following "Top ten reasons why messaging software contributes to productivity:"

- ❑ Updated, critical or time-sensitive information can be sent to one pager or an entire organization instantaneously.
- ❑ Accuracy of alphanumeric messages can be increased through bypassing operator-assisted services and the optional use of a spell-checker.
- ❑ Message senders can send pages from their PC workstation instead of having to change position to a hardware alpha-entry device.
- ❑ Dispatch time is reduced by direct dialing into the message carrier.
- ❑ Confirmation is given that the message was sent and received successfully, allowing the message to be re-sent or re-routed if not received.
- ❑ Storage and instant access to frequently used or repeated messages is available.
- ❑ All pager information is stored in a central database, eliminating the need to look up or memorize messaging carrier information, PINs, access numbers or group codes.
- ❑ Text pages can be linked to existing email programs.
- ❑ Delivery scheduling can be arranged for text pages, such as reminders or appointments.
- ❑ Management and tracking of pages through a log, or hard copy, allows both the sender and the recipient to keep records.



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subscriber's voice pager for the system is not only able to store multiple messages but also permits the subscriber to play, replay, fast-forward and delete messages. As with other pagers, the voice pager

alerts the subscriber of incoming messages using either tone or vibration.

Infrastructure support

A crucial aspect of the infrastructure is its ability to move the data for the voice message to where it is needed, when it is needed. Several factors must be considered:

- ☐ Data compression.
- ☐ Frequency reuse.
- ☐ Data flow management.

► **Compression of voice data** — For a given operator, the least tolerant constraint that influences system design is the amount of available RF spectrum. Only so much is available, and adding spectrum can be extremely expensive. As a result, efficient use of this finite resource is critical.

Compression of the voice data allows a greater number of voice messages to be transmitted over the available RF band-

New capabilities for paging systems

Paging is becoming increasingly interconnected with other forms of information flow because of the efficiency and mobility of wireless communication. Software producers are creating programs that establish an interface with workstations and networks. Telamon, Oakland, CA, has created an updated version of its Telalert product for general-purpose voice notification and response. The new release supports a variety of UNIX and NT platforms. The program was originally designed to send pager notifications to support personnel about system or network problems detected by management platforms or help-desk applications. Applications now extend to interactive voice response; electronic sign messaging; modem, email and voice mail; and the relaying of alerts to and from alarm systems. Capabilities added to Telamon's system include support for Skytel's two-way paging and other PCS services that allow field personnel to acknowledge receipt of a trouble ticket and respond to the software without any operator intervention.

In addition to interactive voice, alphanumeric and two-way paging, the software also supports PCS, landline, cellular services and Simple Network Paging Protocol (SNPP). Two other supported functions are escalation and resource scheduling. Fail-safe escalation allows unacknowledged messages sent to paging, voice mail or some other medium to be re-sent using one of the other alternatives, depending on the urgency. Resource scheduling allows the unavailability of the recipient to be considered, based on vacation schedules, off-site work or other conditions. The program won't waste time looking for someone who is not available.

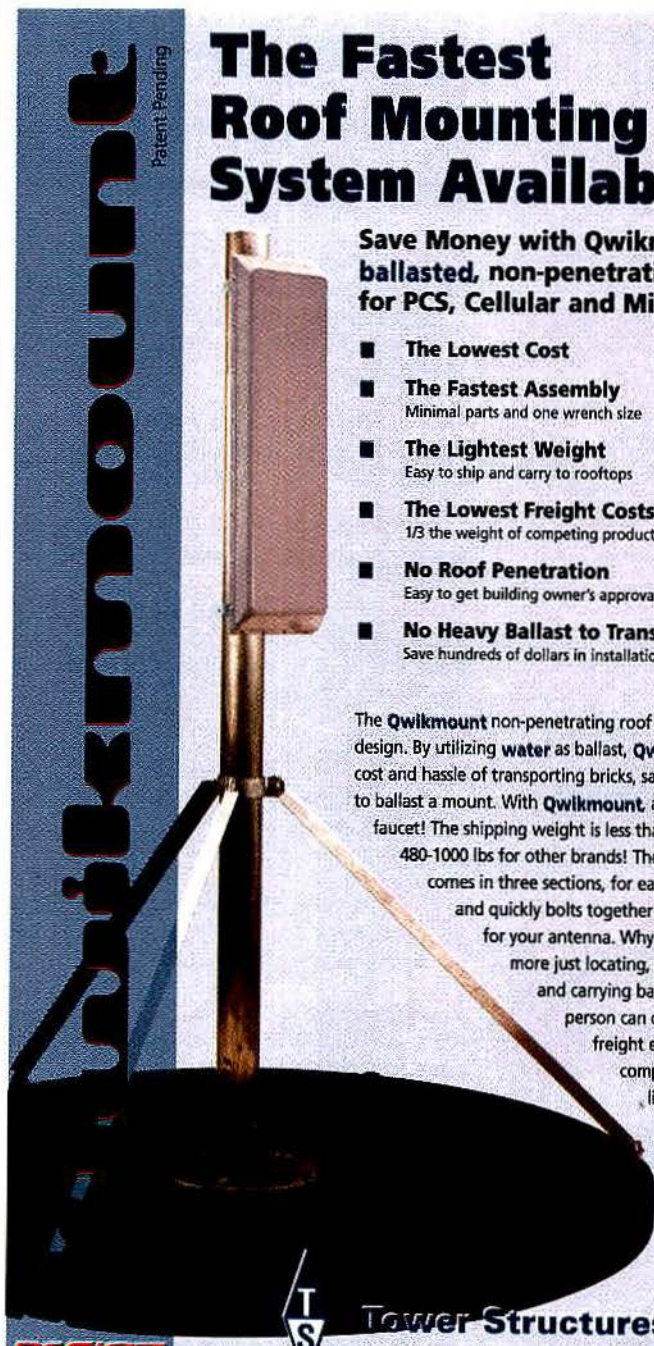


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width. This, in turn, lets an operator place more subscribers into service. An additional benefit is the reduced storage requirements needed to hold messages, pending delivery.

The compression of voice data permits the information to be sent to the pager with minimum latency. For example, a 15-second voice message that has undergone compression can be delivered to the pager using less than 3.5 seconds of airtime.

Although voice compression can be seen to improve airtime use, it also helps reduce network costs. These can be seen directly as costs associated with storage space and networking bandwidth required for each message.

► **Frequency reuse** — The protocol subdivides the frequency spectrum into subchannels. This permits adjacent cells to be transmitting messages to separate paging subscribers at the same time with-

out the cells interfering with each other. Over larger areas, these subchannels can be reused. This permits many separate messages to be transmitted at the same time. This is how voice paging can provide service for a larger number of subscribers.

With the additional subscribers, the paging infrastructure must deliver more messages. This delivery process involves moving data from the home terminal to the controllers and then to the transmitters. As RF efficiency improves and frequency reuse permits more messages to be delivered, the supporting network must be able to handle increasing network loads.

► **Data flow in the paging network** — Even with compressed voice data, excessive or unneeded movement of the data through the network is a wasteful activity that ultimately affects system performance or incurs additional cost. Therefore, strategies exist that attempt to guarantee that only necessary data is moved.

In a traditional, one-way paging network, paging messages are sent from the terminal to appropriate controllers that transmit the data for the subscribed service area. The data is moved for a minimal period, and the basic theory of operation is "Send it, and they will get it—if they are where they are supposed to be." In two-way paging—especially voice paging, which provides for guaranteed delivery—the data is not sent until the pager is located and is prepared to receive the transmission. This paradigm can be used to control the movement of the data in the network.

Until the pager is available and ready, the data need not be sent to the transmitter for transmission. Further, the data need not be delivered to any controller except the one that operates the transmitter for the cell where the pager will be receiving the message. These simple principles can be used to control the data movement and, therefore, the ancillary costs involved in transporting the massive flow of voice data these systems will be handling.

Paging protocol capabilities

The efficiency sought from the infrastructure is supported by specific capabilities of the two-way voice paging protocol. In particular, delivery control is a key feature of the protocol that permits network operational behaviors to be implemented directly. To describe this feature, some background information about the protocol is needed.

► **Communication channels** — The delivery of voice messages involves several communications between the voice

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pager and the infrastructure. These transmissions occur over three separate logical channels:

- ☐ Forward paging control channel.
- ☐ Forward voice channel.
- ☐ Reverse channel.

The forward paging control channel carries the protocol's control messages. This channel is broadcast over a region in a fashion similar to traditional one-way simulcast transmissions. Messages sent

on this channel would address those pagers that are registered in the region.

The forward voice channel is used to transmit the voice data. This channel is not simulcast by multiple transmitters. Each transmitter has its own data to be delivered. Multiple voice channels can be carried in the RF spectrum used by the control channel. Additional spectrum allows for even more available voice channels. These voice channels permit fre-

quency reuse patterns to be established in adjacent transmission areas.

The reverse channel is used by the pager to communicate to the system for message and command acknowledgments. It uses different frequencies than the forward channels.

Pagers monitor the control channels to be informed of voice messages to be delivered. When all is ready, the pager receives its message from the assigned voice channel. When the message has been received, the pager reports its status to the system.

► **Targeted delivery** — Efficient use of the RF spectrum is supported by selective transmission of the "bulky" voice message to the smallest possible area. Send-

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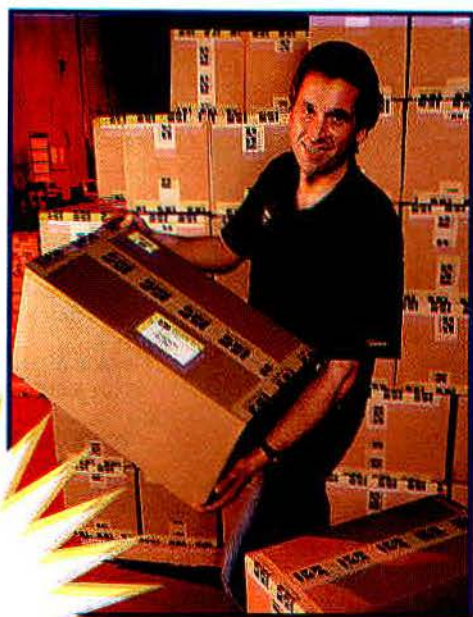
Sending voice message data in a large simulcast area would be wasteful of the available bandwidth. Therefore, the protocol enables targeted delivery.

ing such data in a large simulcast area would be wasteful of the available bandwidth. Therefore, the protocol enables targeted delivery.

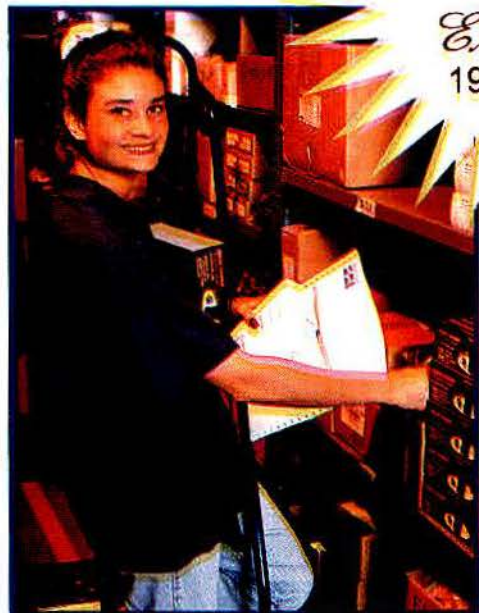
The key to targeting message delivery is "knowing" where the pager is located. This knowledge is maintained using a *hierarchical location model*. At the highest level, terminals maintain information about the pager's location to the zone level. This information is acquired through the zone registrations that pagers perform when they move from one zone to another.

At a middle level in the location hierarchy, a zone may be subdivided into multiple subzones. The division of zones into subzones is managed by the controller. Such dividing is performed, as needed, to support larger population densities. Depending on system requirements, a pager can be instructed to perform location registration as it crosses subzone boundaries. Information related to such crossings is maintained in the controller and is not communicated to the terminal.

The lowest level of the location model is the identification of the "current" transmitter from which the pager can receive a page. This information is only acquired when needed and is not maintained beyond its immediate need. The primary need for this information is in the delivery



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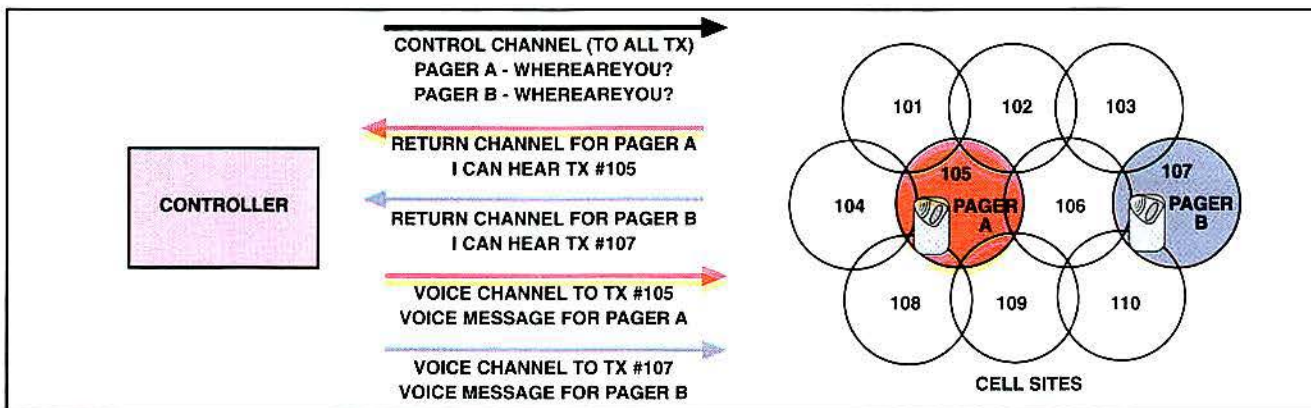


Figure 2. Targeted delivery scenario for two pagers. The red- and blue-filled circles indicate the specific transmitter for each pager.

of voice messages to the pager.

When a new voice message is received by the terminal, it uses its zone information to inform the controller of the need to deliver the message. The controller then uses any associated subzone information to determine where it will look for the pager. This is accomplished with a "WhereAreYou" command. The pager responds to this inquiry, as scheduled, with information regarding the transmitter from which it received the request. The controller uses the transmitter information in

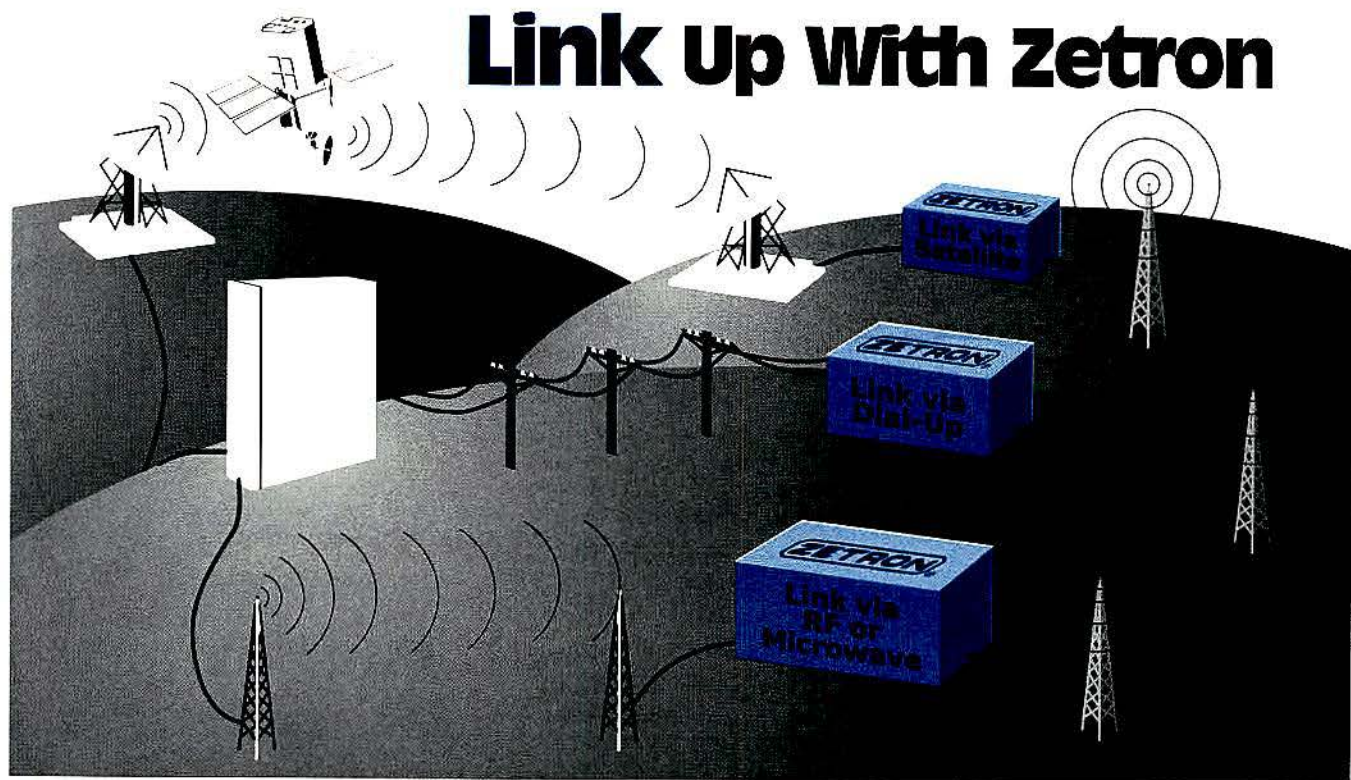
scheduling and broadcasting the actual voice data. The voice data is transmitted on a voice channel of the useful transmitter.

Figure 2 above shows a scenario where two separate pagers, in the same zone, are queried and sent their pages. The patterned areas show the coverage of the specific transmitter that each pager reports "hearing." These would be the transmitters used for the targeted deliveries.

Summary

The success of voice paging will be

partly determined by the efficiency of the data movement through the supporting infrastructure. The initial operators using this protocol (PageNet in the United States and Amtel in Puerto Rico) are commercially operating and validating the success not only of the voice service itself but also of the network infrastructure needed to support it. Lasting innovations in two-way paging will undoubtedly be made in the quest for continued improvement in this dynamic arena.



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Using antennas to improve PCS in-vehicle performance

Degradation of PCS phone signal levels, when used inside a vehicle, is less than that found at cellular frequencies. Test range results confirm, however, that PCS portable use is enhanced by an externally mounted antenna.

By Dale Horn

The new PCS band brings with it the use of portable phones at microwave frequencies. The operation of these phones inside an automobile deteriorates, and performance suffers because of losses attributable to the shielding effects of the metal car body. The following discussion quantifies the performance of a hand-held PCS portable phone operating in an automobile and offers suggestions on how performance can be improved.

One objective that contributes to optimum performance is an omnidirectional signal radiated from the portable. The radiation patterns represent the relative field strength in the horizontal plane. The zero position in the figures is oriented to the front, or forward direction, of the test

Horn is vice president of engineering for the Antenna Specialists Division of Allen Telecom, Cleveland.

vehicle, a sedan. The average signal level was determined by averaging the measured signals in one-degree increments. The important point to recognize is the amount of pattern distortion or nulls caused by signal reflections inside the test vehicle. After attempting to measure the actual radiated signal from a portable phone held by the driver, we determined that the variations attributable to the position of the portable in relation to the driver were not repeatable. Hence, the driver and portable phone were replaced with a standard halfwave, vertically polarized, dipole antenna mounted off the headrest in a position simulating an actual portable antenna. This resulted in

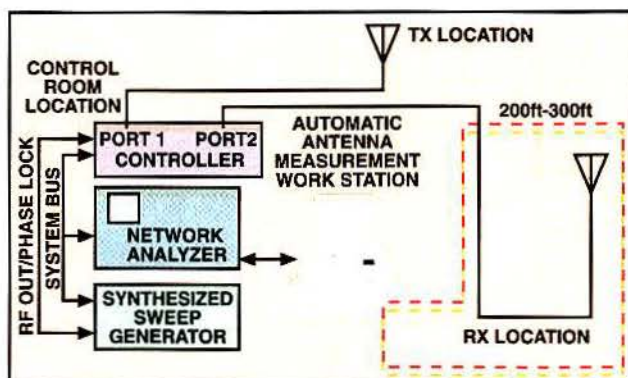


Figure 2 . Block diagram of signal-level measurement system.

credible measurements in lieu of a person holding a portable, which might result in questionable portable phone efficiencies.

The method of measurement began with the construction of a halfwave reference antenna tuned to 1,930MHz. The center-fed dipole was fed through a coaxial quarterwave balun, which was part of a 50Ω air line, terminated in an N

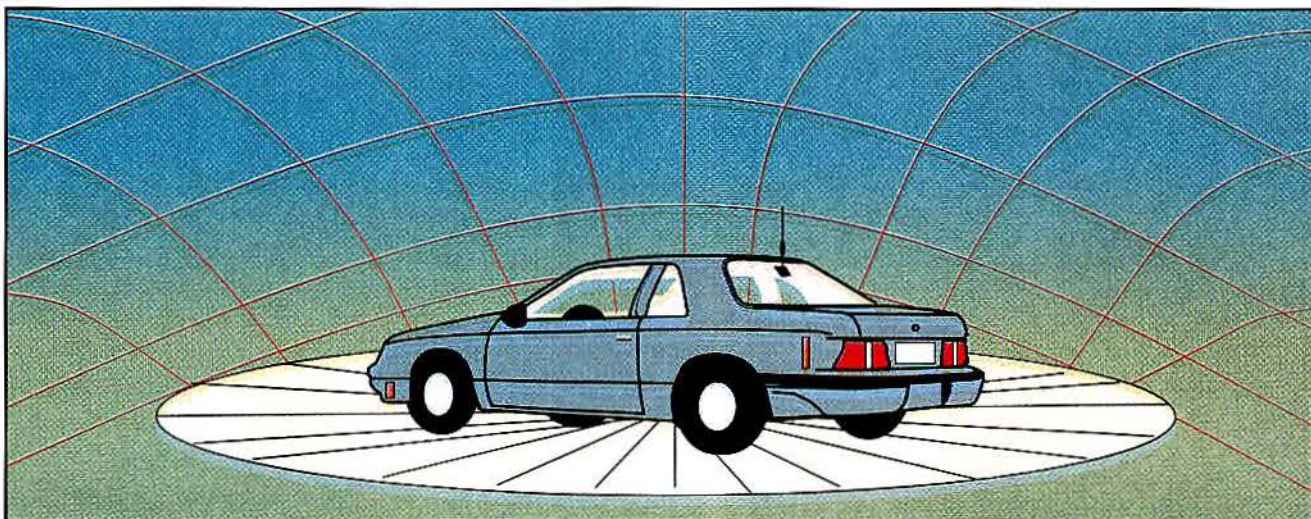
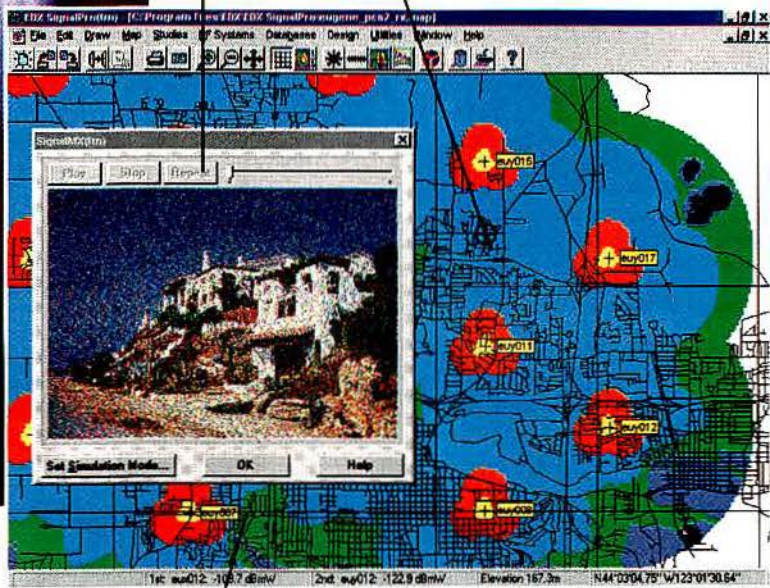


Figure 1. Test vehicle placed in position on the test range.

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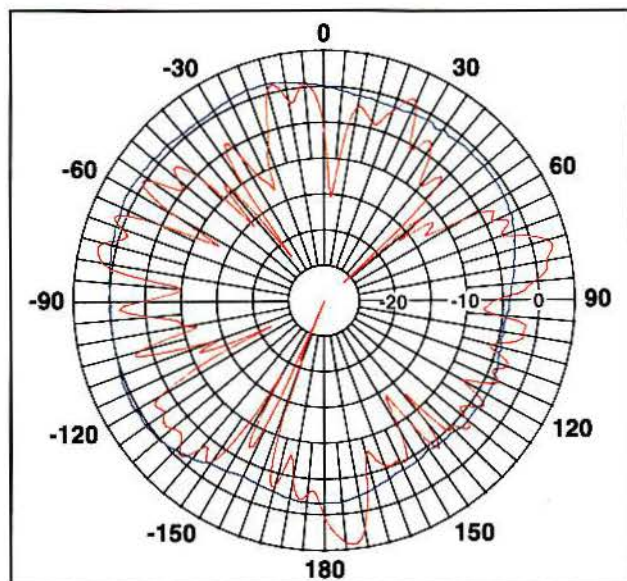


Figure 3. The blue line is the antenna pattern of a free space halfwave dipole. The red line is the antenna pattern of a halfwave dipole placed in the driver's position. (The zero position in all patterns shown corresponds to the front of the test vehicle.)

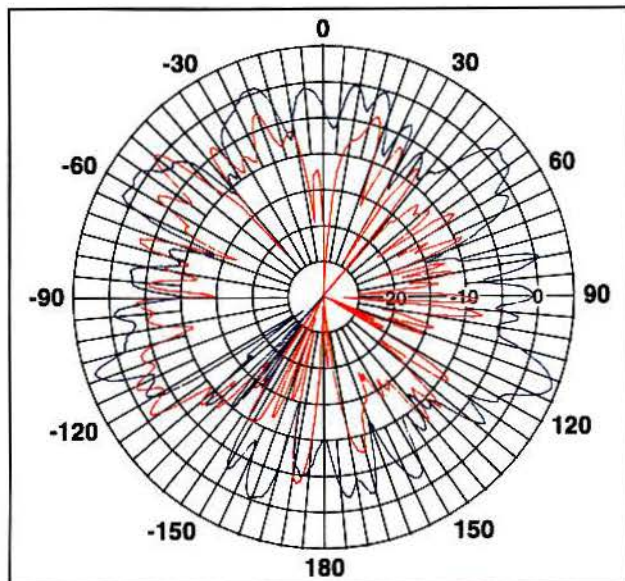


Figure 4. The blue line is the antenna pattern of a halfwave dipole in the driver's position. The red line is the antenna pattern of a halfwave dipole hand-held by the driver.

connector. The halfwave dipole reference was mounted on a five-foot fiber glass support pole and positioned on the center of a 24-foot-diameter ground level car

rotator, as shown in Photo 1 on page 20. Probing the test range with the dipole showed a field-strength variation of less than 0.75dB over the vertical aperture

between the bottom of the window opening and approximately 12 inches above the roof line of the vehicle. The test range used is a 200-foot, outdoor, ground-level

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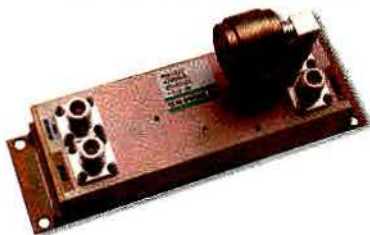
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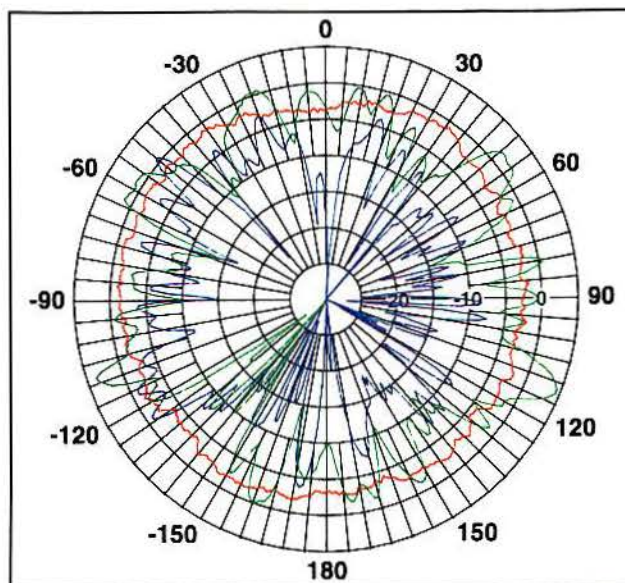


Figure 5. The blue line is the antenna pattern of a hand-held dipole. The red line is the antenna pattern of a quarterwave roof-mounted antenna. The green line is the antenna pattern of a dipole inside the test vehicle.

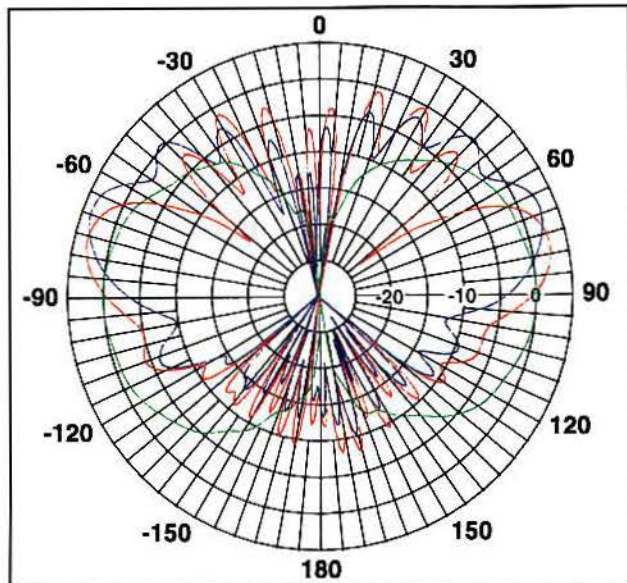


Figure 6. The blue line is the antenna pattern of a quarterwave antenna on the test ground plane. The red line is the antenna pattern of a collinear antenna on the test ground plane. The green line is the antenna pattern of a free-space halfwave dipole.

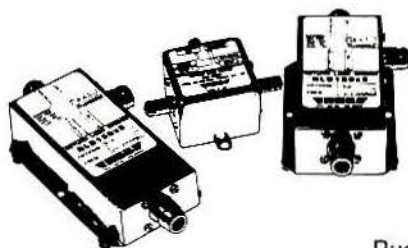
range. A block diagram of the instrumentation for recording test results is shown in Figure 1 on page 22. A frequency-synthesized, phase-locked signal was used

to obtain the data and accurately generate the patterns.

The reference signal level was measured for the free-space, halfwave dipole

located at the test vehicle roof line. The reference dipole was replaced by the test vehicle, which was then rotated with the reference dipole in the same position that

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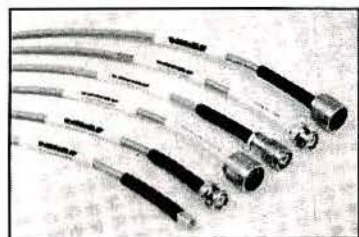
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the portable antenna would be located if held by the driver. Figures 2, 3 and 4 show the pattern distortion attributable to operating inside a vehicle. Figure 2 on page 22 shows the pattern of the halfwave dipole inside the vehicle overlaid on the same dipole in free space with the vehicle removed. The nulls, as much as 20dB deep, are attributable to signal scattering caused by the vehicle. To the extent that an average signal has meaning, the signal level of the dipole inside the vehicle is about 3dB less than the free-space, half-wave dipole.

Figure 3 on page 22 shows the effect of a driver holding the dipole as though he were talking on a hand-held PCS phone. The nulls are much deeper, and in some directions, there is an additional signal loss of 5dB-10dB. The average signal level is 5dB less than the dipole without a person holding it. This is probably the best-case loss, because the efficiency of the portable phone and the actual positioning by a portable phone user will only deteriorate the signal further.

The free-space dipole is an excellent reference. However, in the real world, quarterwave and collinear antennas are used on vehicles. Therefore, it is neces-

sary to tie the performance of the portable phone to a standard, externally mounted antenna. Figure 4 on page 24 compares a dipole inside the vehicle with a quarter-wave whip on the roof of the vehicle. Notice that the roof-mounted quarterwave has an omnidirectional pattern and nicely fills in the nulls that result from using the portable phone inside the vehicle.

Figure 5 on page 24 shows that a quarterwave monopole has a vertical half-power beamwidth of about 22° and a positive major lobe beamtilt of 20° above the horizon. The major lobe gain of the monopole on an 8λ ground plane is +3dB relative to the halfwave dipole in free space. This

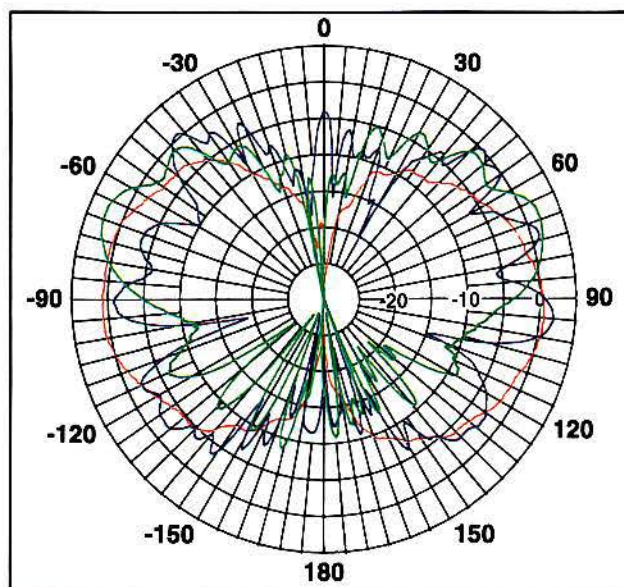


Figure 7. The green line is the antenna pattern of a quarterwave antenna on a 48-inch test ground plane. The blue line is the antenna pattern of a dipole between two slots. The red line is the antenna pattern of a halfwave dipole in free space.

same pattern shows that the performance of the quarterwave can be improved by lowering the major lobe through the use of a two-element collinear antenna design.

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Figure 5 also shows that the gain of the two-element collinear is +3dB greater than the quarterwave and is essentially equal to a halfwave dipole in free space when measured at the horizon.

Two-ground plane tests

To further understand these signal levels, we undertook a series of vertical plane patterns. These patterns were made using two large ground planes which represented

the car roof and the metal at the lower window level. Two metal disks, 48 inches in diameter (representing an 8λ ground plane) were fabricated.

The two-ground plane test was conducted to determine the shape of the vertical (elevation) plane pattern. The test consisted of mounting the two disks 16 inches apart, then mounting the halfwave dipole 7 inches below what would represent the roof of the car and then rotating

the system to produce a vertical plane radiation pattern. The 16-inch spacing was chosen to represent the average height of the window opening on a car. This is a 2.75λ aperture at 1.9GHz, considerably larger in terms of wavelengths than at 450MHz or 900MHz. The four metallic supports represent the support pillars on the car. Figure 6 on page 26 shows a vertical plane pattern with the quarterwave on a single 48-inch ground plane, vs. the halfwave dipole between the two disks, vs. the halfwave dipole in free space as a reference. The halfwave dipole between the two disks shows a multilobe pattern, with one of the lobes near the horizon and within a couple of decibels of the halfwave dipole in free space. The data gathered in this plane can be used to explain why the signal levels measured in the horizontal plane on the car, at the horizon, show a -5dB average signal strength when compared to a halfwave dipole.

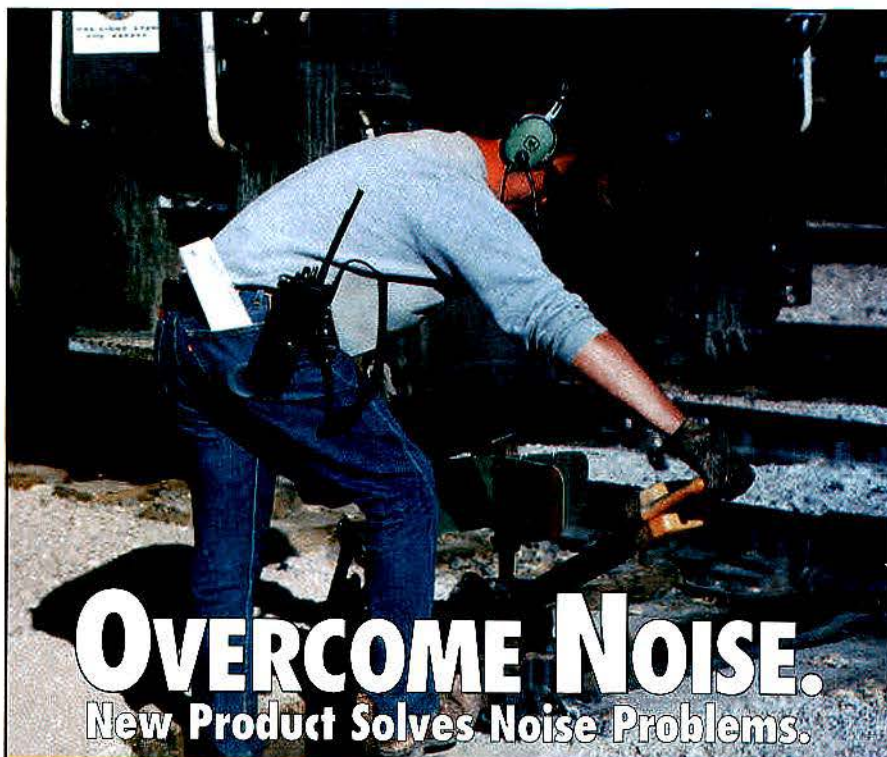
The use of a two-element collinear antenna design on the same 8λ ground plane reduces the beamtilt from +20° to +11° above the horizon, as shown in Figure 6. The beamwidth and gain is essentially the same as the quarterwave in the major lobe.

Conclusions

The average signal level from the standard antenna operating inside the vehicle, without any passengers, is about 5dB below the same antenna in free space. Further, the pattern distortion caused by a passenger operating the phone inside the vehicle increases the loss. The best solution to regain some of this signal loss is to use an external, vehicle-mounted antenna. The use of an external, collinear antenna, such as an Antenna Specialists' ASPM1954T, would not only increase signal level but would also eliminate the effect of the nulls in addition to the benefit of an omnidirectional pattern.

The use of an externally mounted antenna will improve the performance of the PCS portable in two respects: It will provide gain over the antenna on the portable, and it will further enhance signal coverage.

The good news is that the vehicle's degradation of portable phone performance at PCS frequencies is less than what has been demonstrated at cellular frequencies. However, the efficiency of the portable, together with the relatively small size of the antenna, results in in-vehicle system performance that is even more user-dependent than cellular. The best solution is an external antenna, or an active mobile repeater placed inside the car and hardwired to an external antenna.



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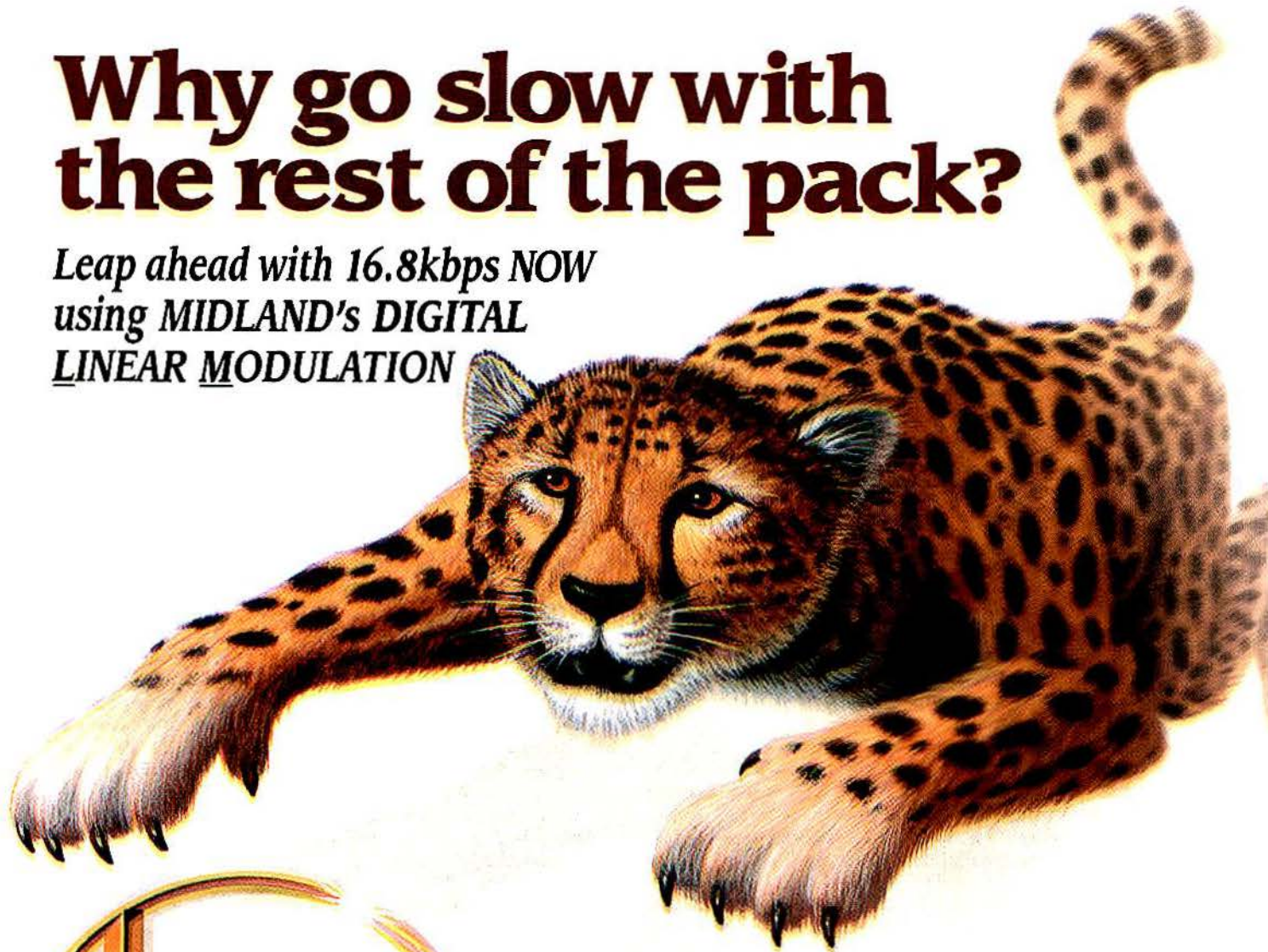
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Superconductor technology for wireless networks

The use of superconducting RF filter subsystems in cellular receivers allows reduction of interference from out-of-band sources, enhances sensitivity, increases call clarity and reduces dropped calls.

By Stephen M. Garrison

In 1911 the properties of superconducting materials were first discovered. In 1986, advances in ceramic compounds created the possibility of applying superconducting materials to more commercial applications without the cost and complexity previously required to achieve extremely low temperatures.

New combinations of oxides, with phenomenal properties, continued to display extraordinary possibilities. These new, complex ceramic oxides came to be known as high-temperature superconductors (HTS) because they exhibit superconducting behavior at significantly higher temperatures—where more reliable refrigeration systems are commercially available. Migration of HTS into the com-

mercial arena was just a matter of time.

Conductus turned its experience and successes with laboratory instruments into a newer field—wireless communications infrastructure equipment. Using a yttrium-barium-copper-oxide-based superconductor, we produce HTS components using “thin-film” fabrication approaches similar to those used in the semiconductor industry. Superconducting systems containing many filters can be packaged in a significantly smaller footprint than conventional filters. This is critical to wireless networks concerned with the amount of “real estate” filters require.

The application of HTS materials was found to be extremely beneficial in all “passive” electronic components. The same principal challenge that dominated nuclear magnetic resonance (NMR) (a chemical diagnostic procedure), namely,

reducing the loss of RF components and enhancing the signal-to-noise ratio (SNR) performance, could be addressed with the use of HTS.

Superconducting RF filters are far superior to conventional filters in their ability to reject adjacent, out-of-band radio signals. The receiver subsystem we developed demonstrated the ability to reduce interference from out-of-band sources, to enhance reverse-path or uplink sensitivity, to increase call clarity and to reduce dropped calls. In areas such as rural cellular networks, the cost savings resulting from implementing the receiver subsystem to improve coverage have proven to be significant compared with building new cell sites.

Enhanced base station sensitivity, in particular for low-power (0.6W) portable handsets, can be characterized by uplink-SINAD (signal-intensity-noise and distortion) measurements. A 1dB reduction in receiver noise floor or figure enhances SINAD by 3dB in the fade margin or typical hand-off region—where received signal strength indicator (RSSI) units are in the -100dBm to -85dBm range, as shown in Figure 1 at the left. As a result, call clarity is enhanced and fewer hand-offs fail. Values of 18dB SINAD are considered the minimum desired value for maintaining analog sound quality. As SINAD decreases to 12dB and less, calls become filled with “popcorn” or “scratchy” artifacts of low received-signal strength and are typically dropped.

The reduction in interference offered by HTS filters is a result of their higher Q factor. Because these materials exhibit

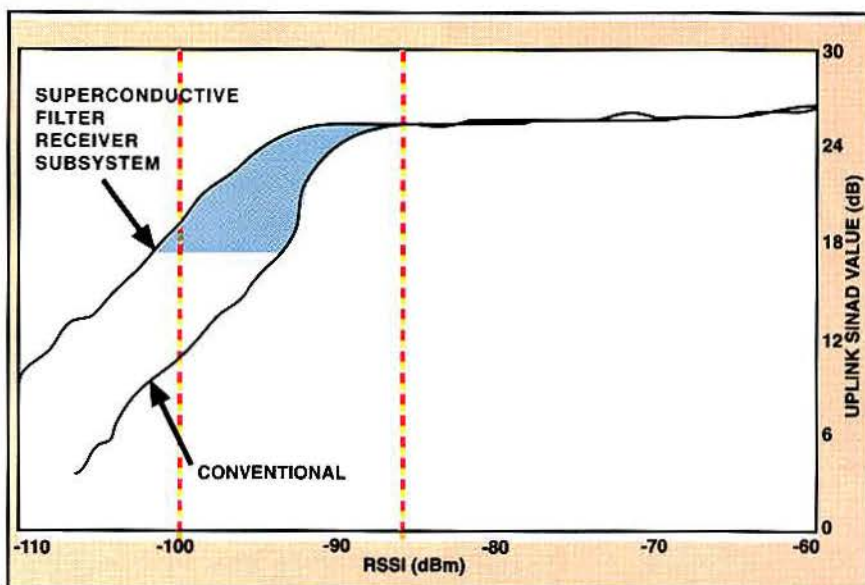
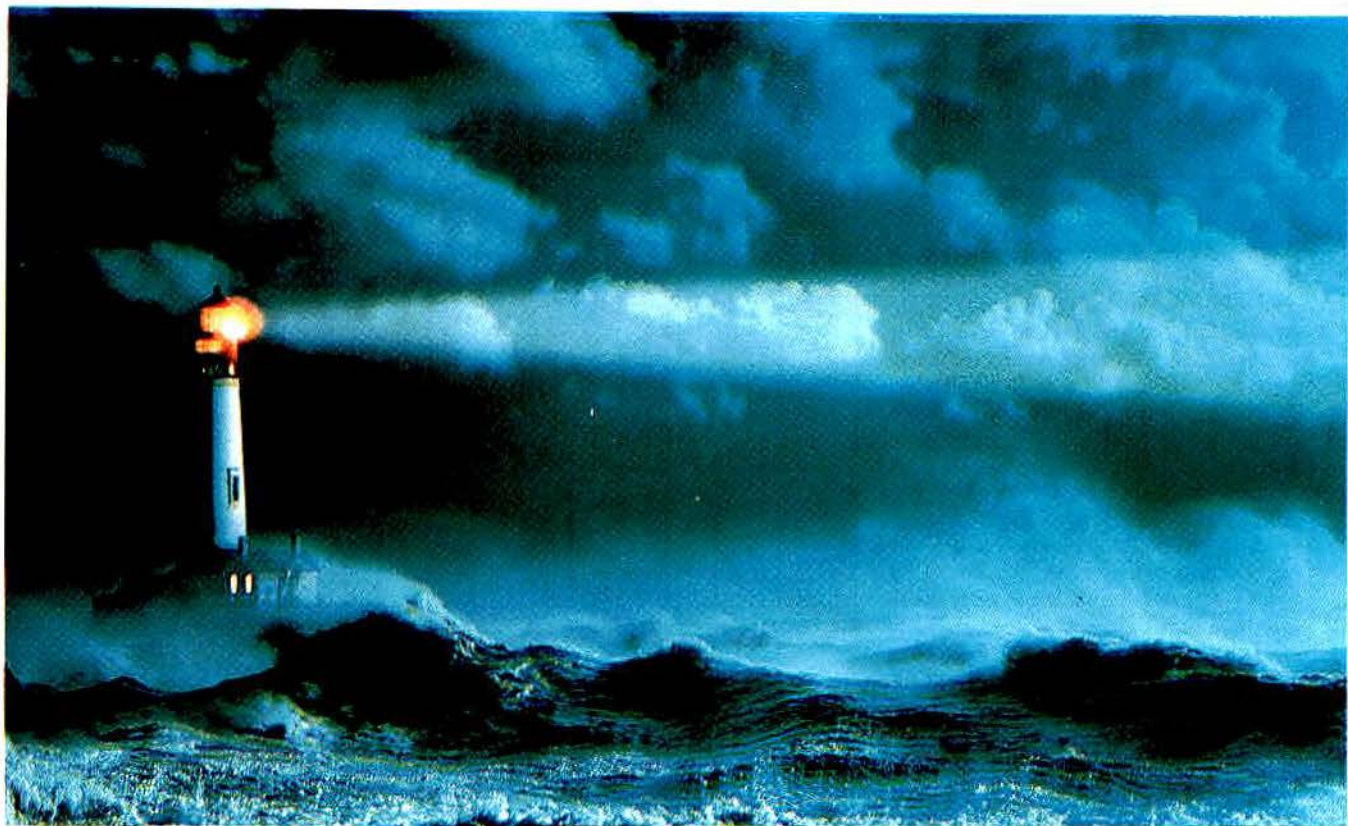


Figure 1. A 1dB reduction in receiver noise floor or figure enhances SINAD by 3dB in the fade margin or typical hand-off region—where received signal strength indicator (RSSI) units are in the -100dBm to -85dBm range.

Garrison is product marketing manager, wireless, for Conductus, Sunnyvale, CA.

The receiver subsystem described in this article has been trademarked by Conductus under the name ClearSite.



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low loss, RF designers can incorporate more resonators or poles into their filter designs. The filter rejection skirt can then be made to roll off much faster than conventional technology, although still providing less in-band insertion loss. HTS filter skirt roll-off performance can exceed 60dB of attenuation only 1MHz away from the band edge. This new benchmark in filter performance is promising for reducing PCS-to-PCS interference as personal communications services acquire subscribers.

In the spring of 1997, beta tests with rural carrier Cellcom, Green Bay, WI, fulfilled HTS projections. Rural markets, by their very nature, have lower revenue streams than dense urban markets. As a result, carriers prefer alternative network solutions that bypass the need to erect more cell sites. It is not cost-effective to put in base stations every 40 miles. Carriers must depend on equipment that extends the range of the transmitted portable handset signal and maintains the integrity of call clarity.

Cellcom participated in the first rural trial of four receiver subsystem beta units. In the period of testing, the primary goal was to determine whether the technology

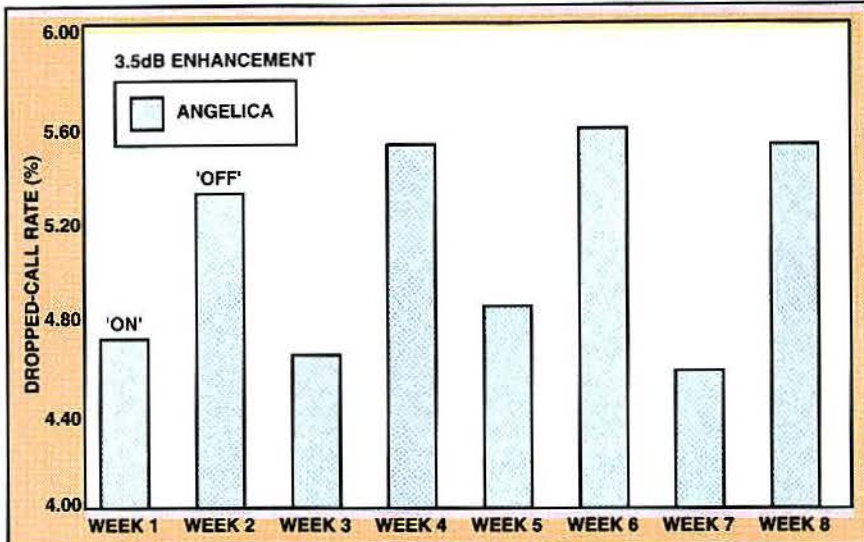


Figure 2. The Wisconsin trials used the system's on/off ability to test the percentages of dropped calls. Over an eight-week period, the various testing sites produced results with measurable decibel enhancement.

would be able to address the sensitivity issue. A significant reduction in interference would aid the carrier in its battle with numerous interference sources, such as nearby paging base station antennas or signals from competing cellular opera-

tors' subscribers. Cellcom easily integrated the receiver subsystems at the four sites in less than two hours of installation time per site (and with the approval of its network equipment supplier).

The challenges to Cellcom's network

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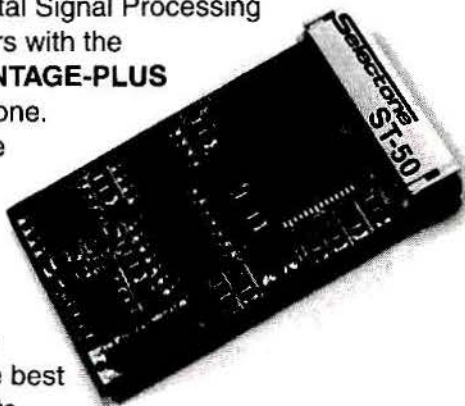
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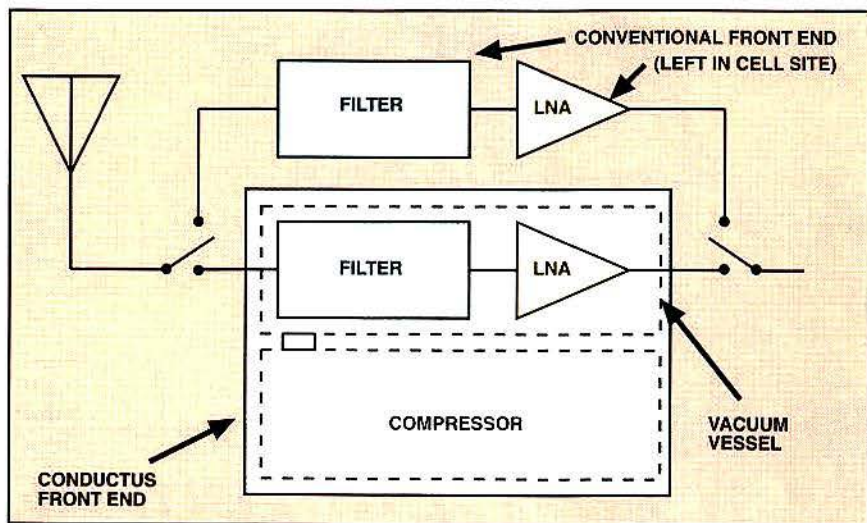


Figure 3. Configuration of the receiver subsystem equipped with superconductive filter.

can be primarily traced to the increased use of lower power (0.6W) portable handsets that the network sometimes has difficulty hearing.

The trials showed a marked improvement in both the dropped-call rate and in the call clarity, as qualified by a focus group of key customers in the upgraded

territories. The improved quality of service was the result of a 2dB–4dB reduction in the base station noise floor or noise figure. This reduction in noise floor, when paired with high Q-factor HTS filters, is a significant step toward maximizing the performance of a carrier's network.

As shown in Figure 2 on page 32, the

trials used the system's on/off ability to test the percentages of dropped calls. Over an eight-week period, the various testing sites produced results with measurable decibel enhancement.

Figure 3 at the left shows the configuration of the receiver subsystem. The use of HTS technology allows designers to evaluate the configuration and relationship of Q factor and noise floor with reduced interference and dropped calls. This knowledge gives designers an edge in their networks. The combined receiver and cryogenic refrigeration system is designed for five years of maintenance-free operation. These systems can be wall- or rack-mounted in the equipment room or mounted on the tower, as with tower-mounted amplifiers.

The combined advantage of superconducting systems is that they maximize coverage of existing infrastructure by increasing base station sensitivity, and they enhance receive isolation, protecting the network from out-of-band competing wireless services. These combined features offer operators a cost-effective means to enhance network quality of service.



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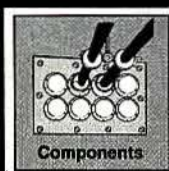
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Predicting power density near antennas to meet FCC RF safety regulations

The majority of potential RF hazard zones at a site occur in the near field, resulting in the necessity to predict both the near and the far field power density of an antenna array.

By Robert Mawrey, PhD, Terry Riley, James Higgins and Steven Slayden

In August 1996, the FCC issued a new report and order on human exposure to radio frequency radiation (1). According to the FCC, changes to the rules mean that over 12,000 antenna installations per year will require evaluation to determine their compliance with the new regulations.

In the past, operators of low-power services, such as cellular, paging, private land mobile and PCS, were not required to address the issue of potential human exposure to radio frequency emissions at their radio sites. The low potential for exposure at such sites had been considered sufficient grounds by the FCC to "categorically exclude" most operators from considering human exposure hazards.

Based on new data, the FCC revised the rules to consider the height of sites above ground and the cumulative operating power at sites. Now, most wireless operators are no longer categorically excluded from analyzing their sites, particularly at shared rooftop sites where the cumulative operating power exceeds the threshold. Furthermore, low-powered systems are not necessarily exempt from safety considerations. According to the new rules, operators with transmitters contributing more than 1% of power density share the responsibility to ensure compliance in areas that exceed the exposure limit.

To meet the FCC enforcement deadline of Sept. 1, 1997, operators across the

country are developing programs to ensure that their sites are in compliance with the new FCC guidelines. According to many safety experts, including OSHA (2), the most important way to ensure compliance with FCC RF health and safety rules is for operators to implement their own comprehensive health and safety program.

To help wireless operators implement their own programs, industry associations such as the CTIA and the PCIA have, or are working on, RF safety manuals (3). Practical steps involved in the implementation of a health and safety program include:

- Developing written RF health and safety policies and procedures.
- Implementing policies and procedures, including training of staff and contractors.
- Surveying new and existing sites to gather antenna and radio data.
- Determining which sites are not categorically excluded.
- Determining site compliance by analyzing or measuring its power density.

Methods describing how to measure RF power density are published in a report by the Institute of Electrical and Electronic Engineers (IEEE) (4). The FCC provides guidelines on how to analyze or predict power density at a radio site (5). In most cases, it is more cost-effective to determine compliance by predicting power density at a site than it is to take measurements.

Predicting RF power density

FCC guidelines provide approximate models that may be used to calculate power density at AM, FM and television broadcast stations, as well as near aperture antennas (5). According to the FCC, cellular and PCS operators will perform

47% of new RF exposure evaluations. So-called omnidirectional and panel antennas are most commonly used by cellular, PCS and paging operators, but *the existing FCC guidelines do not provide methods of predicting power density near these type of antennas.*

The power density surrounding an antenna varies as a function of location and is dependent on distance and orientation. The fields around an antenna may be divided into two principal regions, one near the antenna called the *near field* and one at a large distance from the antenna called the *far field* (6). The boundary between the two is often taken to be at the radius

$$R = \frac{2L^2}{\lambda}$$

where L is the maximum dimension of the antenna and λ is the wavelength.

In the far field, the shape of the antenna pattern is independent of distance. In the near field, the shape of the field pattern depends on the distance, R . Antenna patterns published by manufacturers are typically only applicable in the far field and therefore are only applicable for power density calculations in the far field of the antenna.

For high-gain arrays at broadband PCS frequencies, this boundary can be at a significant distance from the antenna. At broadband PCS frequencies (~1,900MHz) the boundary between the near and the far field is 50m for a 2m antenna. The majority of potential RF hazard zones at a site occur in the near field, resulting in the necessity to predict both the near and the far field power density of an antenna array.

Rigorous analytical techniques and software methods are available that predict fields surrounding antennas (7). These


Mawrey is director of RF engineering, Riley is staff RF engineer, Higgins is software scientist and Slayden is staff software scientist for the UniSite RF engineering firm, Richardson, TX.

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techniques typically model antennas as small wire elements and metal plates, with some of the elements fed by signal sources. These methods have a practical limitation, however, because they require detailed information on the physical structure of the antenna that is typically not available. Other less rigorous techniques have been developed to obtain adequate estimates of power density near antennas. These techniques make use of available information, including the physical dimensions and the published gain patterns of the antennas.

Far field model

In the case of a single radiating antenna, as described by the FCC (5), a prediction for power density in the far field of the antenna can be made by using the following general equation:

$$S = \frac{PG_i}{4\pi R^2}$$

where S is the power density, P is the power input to the antenna, G_i is the gain of the antenna relative to an isotropic radiator and R is the distance to the center of radiation.

An alternative expression is:

$$S = \frac{EIRP}{4\pi R^2}$$

where $EIRP$ is the effective isotropically radiated power.

This model can be modified to consider both ground reflection, Γ , and the gain of the antenna or $EIRP$ in a particular direction as:

$$S = \frac{\Gamma EIRP(\theta, \phi)}{4\pi R^2}$$

where $EIRP(\theta, \phi)$ is the antenna $EIRP$ at a particular azimuth, θ , and elevation, ϕ , is found by extrapolating the published horizontal and vertical gain patterns of the antenna to form a three-dimensional antenna gain pattern.

Near field models

A method of estimating the power density in the near field of a collinear omnidirectional array is described in a technical report prepared for the FCC (8). This *cylindrical method* describes a technique

of predicting power density in the near field of collinear arrays, commonly used by wireless operators, which is useful only in the main beam of the antenna. To overcome this limitation, a new method has been developed that models collinear antennas as an array of elements. This *collinear method* is useful anywhere in the near field of a collinear array.

Cylindrical method

A cylindrical radiation model involves computing the average power density on the surface of a cylinder, with a height equal to the antenna's aperture, and a radius equal to the distance of interest. This is illustrated in Figure 1 on page 40.

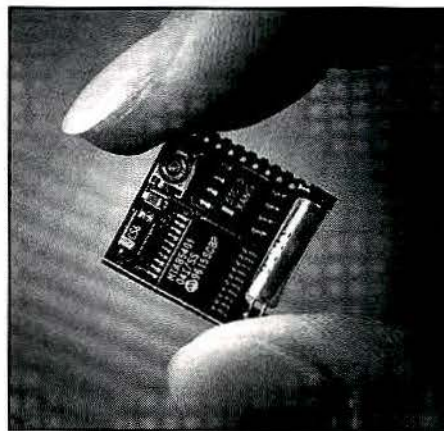
This model is useful in the near field within the aperture of the antenna. Measurement of collinear arrays (8) show that the power density at a fixed height above the surface falls off exponentially as the antenna's height is raised above the surface. The cylindrical model does not reflect this exponential decrease in power density.

Collinear method

By modeling collinear antennas as an

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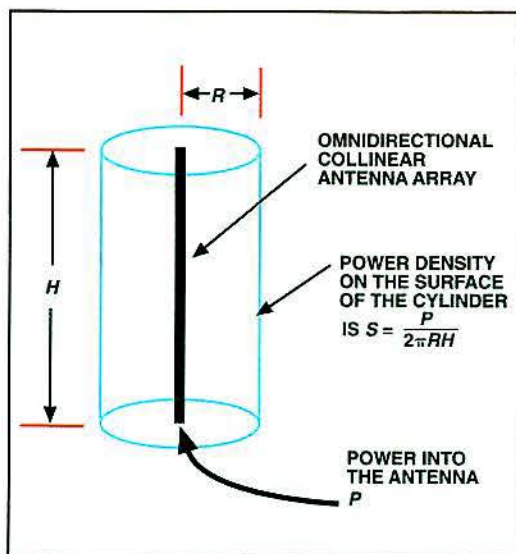


Figure 1. Cylindrical radiation model for computing power density.

array of elements with a length of one-half wavelength ($\lambda/2$), it is possible to estimate the power density of the array in both the near and far field to within approximately one wavelength of the array. The accuracy of this technique is dependent on how well an array of linear ele-

ments, fed in phase, represents the real antenna. In practice, the elements in an array are not necessarily fed in phase. The error introduced by assuming linear phase is, however, small, if the power is averaged spatially over a number of wavelengths. At cellular or broadband PCS frequencies, a human body is about 5λ or 10λ long, respectively. Averaging the predicted power density over the height of a human body at cellular and broadband PCS frequencies provides a reasonable estimate of exposure.

The near field power density of a collinear array is modeled by treating the vertical collinear antenna as an array of N elements spaced one wavelength apart, as shown in Figure 2 on page 42.

The collinear method estimates the number of elements in the array and in the gain pattern of each element. The power density near the antenna is calculated by combining the contributions from each element in the array.

(The collinear method is described in

detail in the sidebar article, which follows on pages 50-54.)

Predicted vs. measured results

The collinear model has been compared against published measured data. A report prepared for the FCC shows measured power density as a function of distance along the main beam of three collinear antennas (8). Some of the data have been published in an earlier paper (9). These published measured data are compared against the so-called cylindrical ($1/R$) model and the collinear method described in the previous section.

Along the main beam

Measurements performed on a Swedcom model ALP-9209 directional collinear antenna, mounted with its center of radiation 1.75m above the floor, were taken along the main beam of the antenna to a distance of 4m from the antenna. The antenna has a physical height of 70cm and a gain of 8.2dBd. The power input to the antenna was 25W. A comparison between measured data in predicted results, using the cylindrical and the collinear array model, is shown in Figure 3 on page 42.

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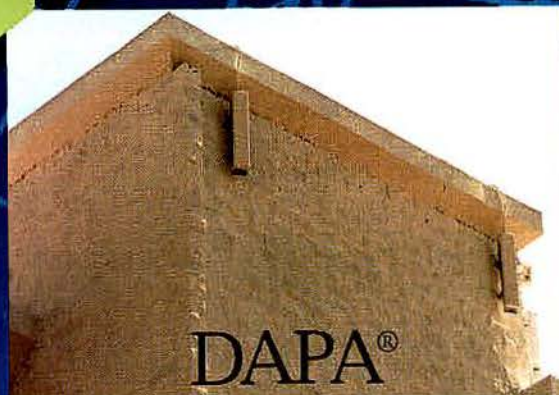
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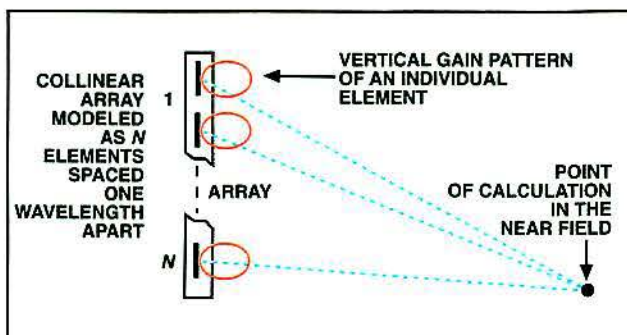


Figure 2. Collinear array model for near field; power density near the antenna is calculated by combining contributions from each element.

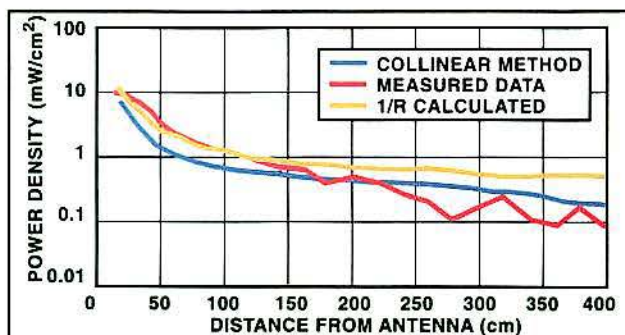


Figure 3. Comparison of measured power density with far field and cylindrical (1/R) model for Swedcom ALP-9209 sector antenna.

Similar measurements were taken from two other antennas. The relevant test parameters are shown in Table 1 at the right.

Figures 4 and 5 on page 44 show the comparison between the measured data and predicted results using both the cylindrical and the collinear models.

These results illustrate that both theoretical methods track the measured results, although the predicted results tend, on average, to be conservative. The data are insufficient to draw statistically significant conclusions, but the results indicate that the average error between predicted and measured values appears to be

less than 3dB for measured data that is not spatially averaged, and less than 1dB for spatially averaged measured data.

Below the antenna

From these results, it is clear that both

models are adequate for predicting power density in the near field within the main beam of the antenna. In many cases, predicting the decrease in power density as a function of height below the antenna is also a requirement. This situation is

Table 1. Test parameters for two antennas.

| Antenna make | Gain (dBi) | Height of radiation center (m) | Antenna length (m) | Power (W) |
|--------------------------|------------|--------------------------------|--------------------|-----------|
| Decibel Products dB 586 | 6 | 1.02 | 1.05 | 25 |
| Decibel Products dB 809K | 9 | 3.83 | 1.95 | 160 |

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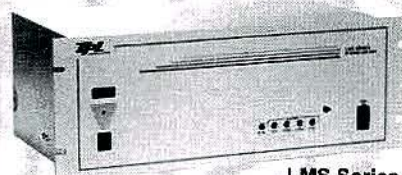
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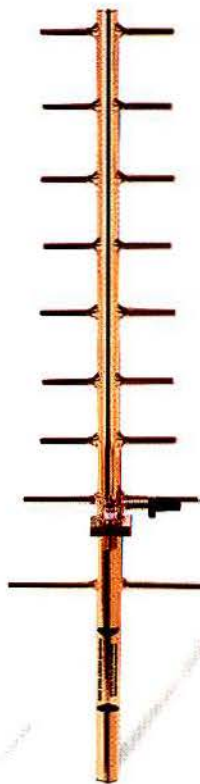
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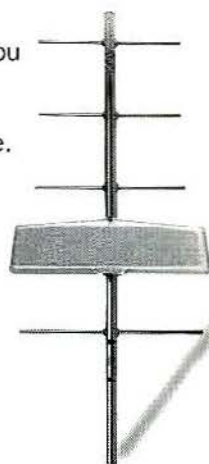


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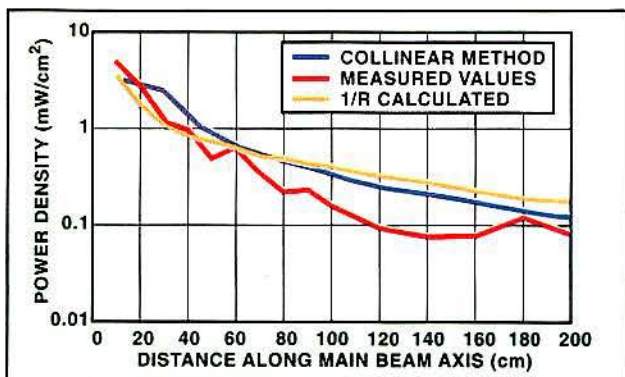


Figure 4. Measured and calculated power density along main beam axis of Decibel Products dB-586 antenna.

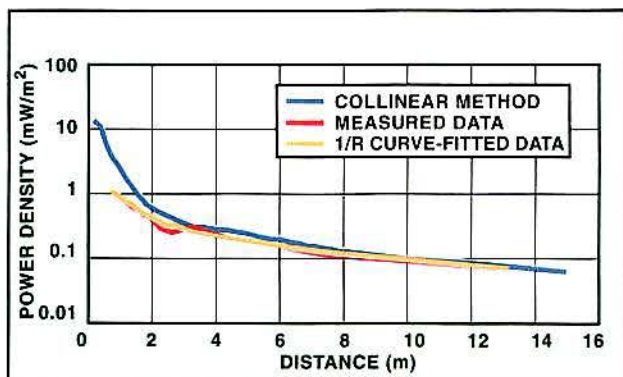


Figure 5. Measured and calculated density along main beam axis of Decibel Products dB-809 antenna (after Peterson and Testagrossa).

particularly important on rooftop sites, where antennas are elevated to reduce exposure on the rooftop. The paper prepared for the FCC (8) provides some normalized measured data that shows the decrease in power density below the antenna at a distance of 4 feet from the antennas. These data have been compared with the collinear method and the results are shown in Figures 6 and 7 on page 46.

The correlation of the predictions to the measured data varies. For the short Swedcom antenna, the predicted results

are conservative, while the predictions for the longer Decibel antenna, that is more representative of a collinear array, correlate more closely. Assuming one wavelength spacing between elements, the Swedcom antenna dimensions appear to provide only sufficient spacing for a single element. For a single-element "array," the array pattern is the same as the element pattern. The Swedcom manufacturer's data sheet describes the antenna as a log-periodic reflector antenna. This is not a low-gain element, and the col-

linear method will simply predict a conservative near field approximation using the far-field gain pattern.

Power density prediction software

Power density prediction software may be used to engineer and manage radiated power density on rooftop and tower sites. The software can generate a three-dimensional picture of a site showing the location of antennas, with power density levels superimposed on the rooftop. These levels may be predicted using software tools.

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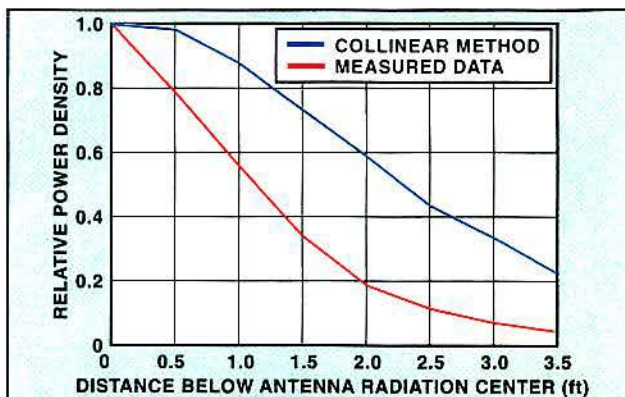


Figure 6. Measured and predicted decrease below a Swedcom ALP 8007 antenna at a distance of four feet.

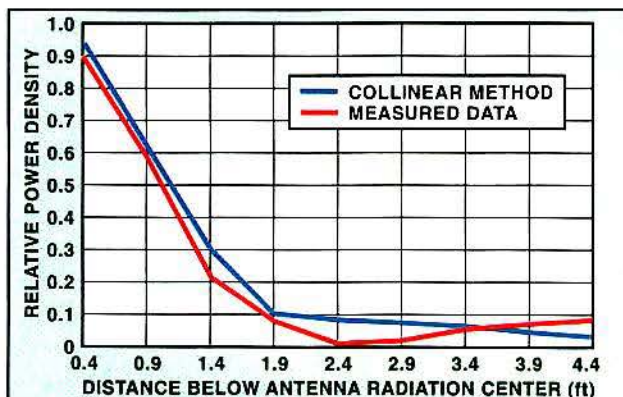


Figure 7. Measured and predicted power density below a Decibel Products dB 833 antenna at a distance of four feet.

As shown in Figure 8 on page 48, a graphical-user interface (GUI) allows a user to specify the structure of a site, to place antennas at the site and to specify the power and frequency of each antenna.

Using the prediction methods described in the previous section, prediction software is used to predict power density as a function of location. As shown in Figure 9 on page 48, the results are displayed graphically as a color plot showing percentage of maximum permissible expo-

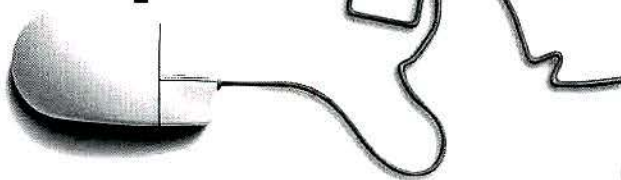
sure as a function of location at the site.

Large wireless operators typically operate thousands of sites across the country that are managed by regional divisions. To ensure uniform compliance with FCC regulations and to coordinate the work of multiple divisions, an operator must keep copies of the analysis and site data at headquarters—typically on file in its regulatory department. A convenient way to do this is to store and to manage the data and analysis results in an elec-

tronic database, preferably in a client-server environment that enables geographically separated groups to work on a centralized database. A software tool may also provide the user with a database that may be viewed and manipulated.

Existing sites should be re-evaluated for compliance as new tenants are added. A software tool that stores the existing site information and analysis results in a database, and which allows the user to add new tenant information and reanalyze

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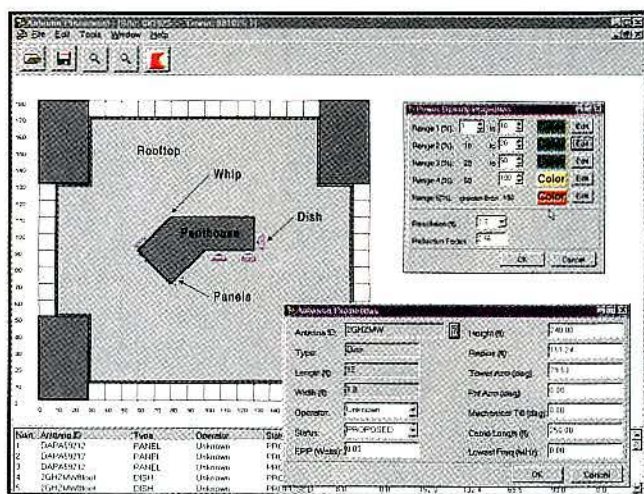


Figure 8. Unisite software using a graphical user interface (GUI) to specify site logistics, power and frequency.

the site, simplifies the compliance determination process.

Conclusion

Ensuring compliance with new FCC health and safety rules must be a critical initiative in any wireless operational strategy. While this may present a new chal-

lenge for many operators, advanced tools are available to simplify the process. As part of implementing health and safety policies that comply with FCC rules, operators will be required to measure or to predict the power density at their radio sites. In most cases, predicting power density is a more cost-effective method.

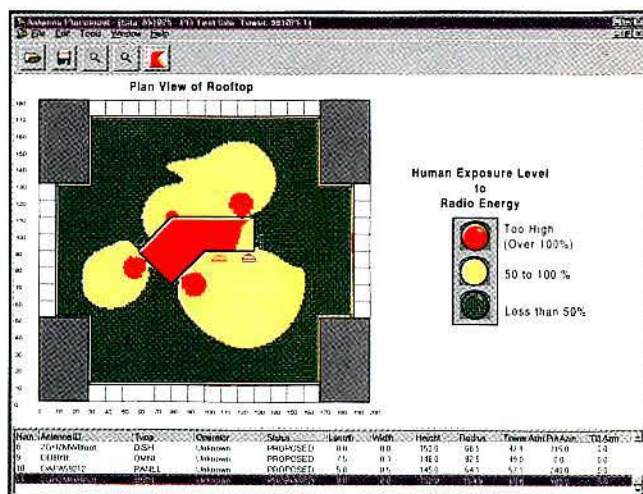


Figure 9. Software displays a color plot showing maximum permissible exposure at various locations at the site.

A method of predicting power density near collinear arrays has been presented and compared with measured results. This method is accomplished easily by using software tools that analyze, store and interpret relevant information about the sites.

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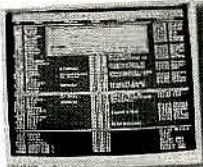
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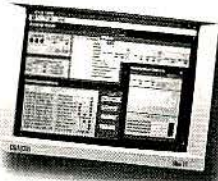
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The collinear method

Estimating the pattern of an element in the array

The following approximation is used to estimate the gain of an individual element in any direction. Data supplied by antenna manufacturers typically includes the far field horizontal and vertical gain pattern and the physical length of the antenna, L . Assuming that the collinear array comprises elements with a spacing of one wavelength, λ , then the number of elements in the array, N , may be estimated as

$$N = \left[\frac{L}{\lambda} - \frac{1}{2} \right] + 1$$

The maximum gain of each element in the array, $G_{El_{max}}$, is

$$G_{El_{max}} = \frac{G_{A_{max}}}{N}$$

where $G_{A_{max}}$ is the maximum gain of the array.

Given the coordinate system shown in Figure 1 at the right, the normalized horizontal gain pattern of each element in the vertical collinear array is estimated to be the same as the normalized horizontal gain pattern of the array $G_A(\varphi)$. In contrast, the vertical gain pattern of each element is not readily extracted from the vertical gain pattern of the array because the shape of the array pattern is highly dependent on the phasing and spacing of the array elements. It is possible, however, to make a reasonable approximation, if the gain of each element is less than about 3dB. The normalized vertical gain pattern of the main lobe of the element is approximated as $G_{El}(\theta) = \cos^3\theta$, where θ is the elevation angle. This pattern corresponds to a vertical half-power beamwidth of 75°.

The gain of each element in any direction is limited to a minimum of 20dB less than the maximum gain of an element. This has the effect of filling in the nulls of the element pattern and is a conservative approximation used to ensure that the gain of the element is not underestimated in any direction.

The gain of an element in any direction is thus

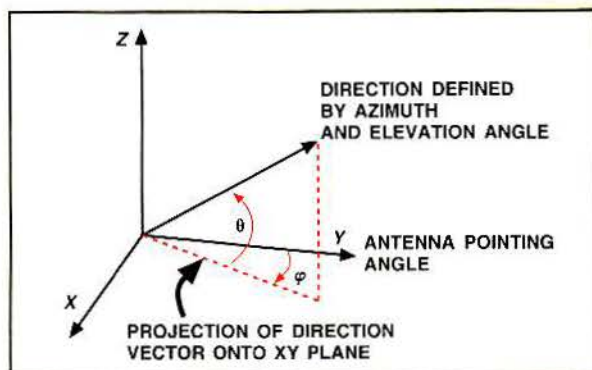


Figure 1. Coordinate system for horizontal gain pattern.

calculated as

$$G_{El}(\theta, \varphi) = \text{Maximum} \left| \begin{array}{l} G_{El_{max}} \frac{G_A(\varphi)}{G_{A_{max}}} G_{El}(\theta) \\ \frac{G_{El_{max}}}{100} \end{array} \right|$$

As an example, consider a directional collinear array with the vertical and horizontal gain patterns as shown in Figure 2 below. The normalized horizontal array pattern is the same as the normalized horizontal element pattern. Note that the vertical array pattern is not used. The vertical pattern is approximated using a $\cos^3\theta$ function, and the element pattern is limited to a minimum gain of 20dB less than the maximum gain. This is illustrated in Figure 3 on page 52.

Calculating power density

The time rate of energy flow per unit area is the Poynting vector (1), or power density (watts per square meter) in the

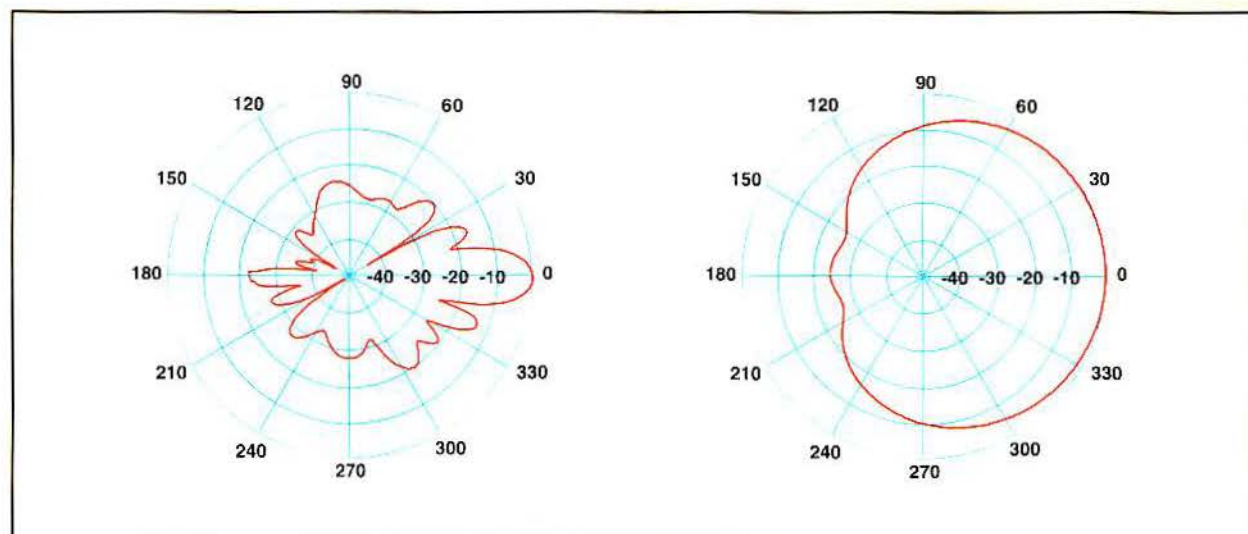


Figure 2. Normalized vertical array polar pattern (dB), left, and normalized horizontal array polar pattern (dB), right.

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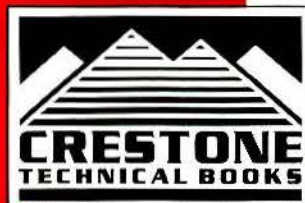
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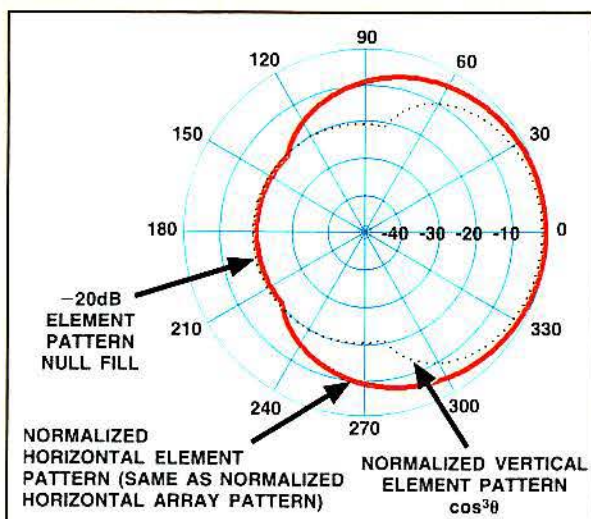


Figure 3. Approximation of the vertical pattern.
far field of an antenna is

$$S_r(\theta, \varphi) = \frac{EIRP(\theta, \varphi)}{4\pi R^2}$$

where $EIRP(\theta, \varphi)$ is the effective isotropic radiated power.
The effective isotropic radiated power from a single

element is:

$$EIRP_{El}(\theta, \varphi) = G_{El}(\theta, \varphi) \frac{P}{N}$$

where P is the power fed to the array. The relationship between $EIRP$, ERP , and P is:

$$EIRP = 1.64ERP = PG_A$$

where G_A is the power gain of the array relative to an isotropic source.

The relationship between the Poynting vector and the amplitude of the total electric field intensity, E , at a point in the far field is:

$$S_r = \frac{1}{2} \frac{E^2}{Z}$$

where Z is the intrinsic impedance of the medium ($Z=377\Omega$ in free space).

The peak electric field from any element at the location of measurement is

$$E_{El}(\theta, \varphi) = \sqrt{\frac{2Z EIRP_{El}(\theta, \varphi)}{4\pi R^2}}$$

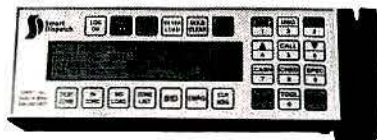
where R is the distance from the center of antenna to the location of measurement.

The signals from the elements have a different amplitude

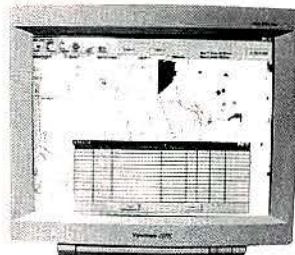
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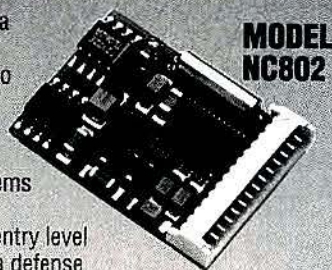
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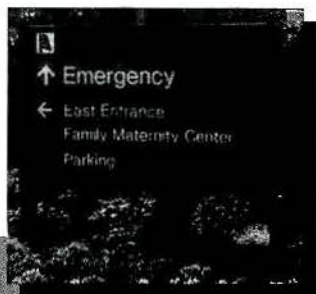
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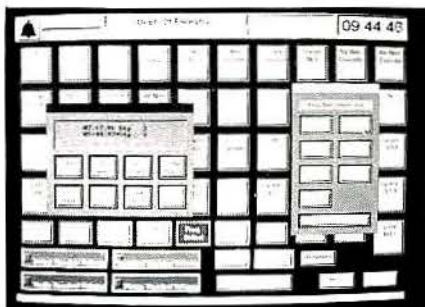
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and a different phase when arriving at the point of measurement. The signals can be added vectorially (or as phasors). Using the center of the array as a phase reference, the relative phase of the i th element is:

$$\phi_{Ei} = \frac{2\pi(R_{Ref} - R_{Ei})}{\lambda}$$

where R_{Ref} is the distance to the center of the array with phase zero and R_{Ei} is the distance to the i th element.

The contribution from each element is broken into its components,

$$X_i = E_{Ei} \cos(\phi_{Ei})$$

$$Y_i = E_{Ei} \sin(\phi_{Ei})$$

$$E_{Ei} \angle \phi_{Ei} = X + jY$$

The X and Y components of each phasor are added and the equivalent root mean square voltage is calculated as

$$A = \sum_{i=1}^N X_i \quad B = \sum_{i=1}^N Y_i$$

The root mean square electric field is

$$E(\theta, \varphi) = \sqrt{\frac{A^2 + B^2}{2}}$$

It may be shown that the average power density is

$$S(\theta, \varphi, R) = \frac{E^2(\theta, \varphi)}{Z} = \frac{A^2 + B^2}{2(377)}$$

Reference

1. John D. Kraus, "Antennas," McGraw-Hill, 2nd edition, 1988.



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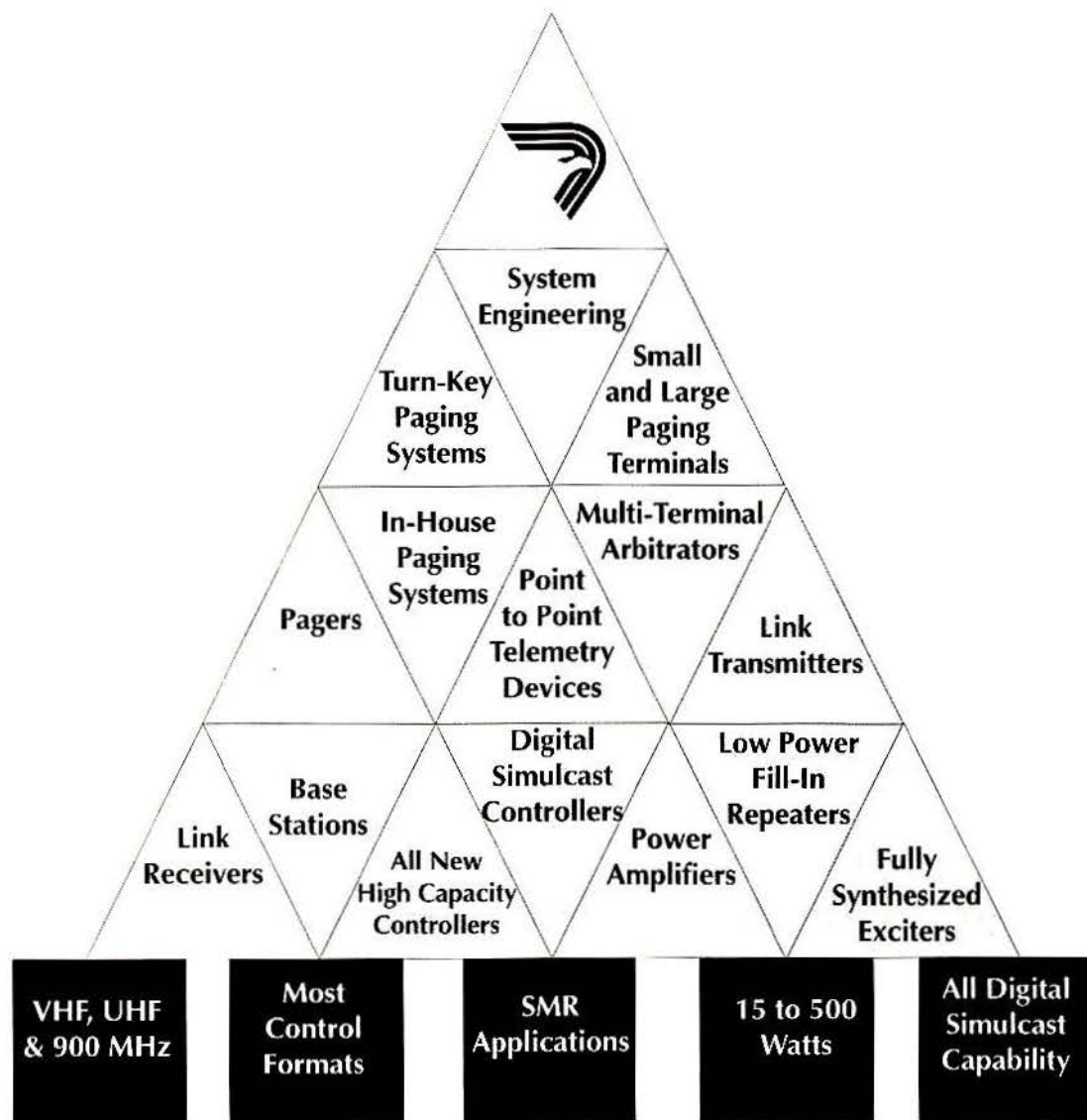
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Data communications: From Pathfinder to public safety

From the Mars mission to applications for public safety and business, data communications technology is experiencing improvements in error reduction, applicability, security and ubiquity.

By the MRT staff

Wireless data communications technology is steadily improving for the mobile environment. Better use of available spectrum, software support, secure transmissions and extended applications all contribute to the adoption of data communication. Some of the applications this year have literally been "out-of-this-world."

Roving around a red planet

It may be worthy of some historical note that this is the first time *MRT* has covered mobile radio technology deployed on another planet. As shown on this month's cover and in the photo below, part of the hardware contributing to the success of NASA's Mars Pathfinder mission is a set of radio modems allowing the six-wheeled Sojourner Rover survey vehicle to communicate with the Lander base station.

For the Mars mission, the Jet Propulsion Laboratory (JPL) elected to use a Motorola RNet 9600 SLM modem, which was designed by Dataradio, Atlanta, and which also uses that company's components. One interesting point about this space hardware is that it is essentially an "off-the-shelf" product designed for terrestrial use.

The "transparent" radio modem is a compact (1"×2.5"×3.3") unit with a built-in 2W UHF transceiver. "Transparent" in this case refers to the modem's transmission of characters exactly as they are presented to the RS-232 port, without adding packetization, addressing or error checking. This minimizes delays for use with other protocols that handle those additional functions for Pathfinder and reduces the earth-bound data throughput by other systems to about 2,400bps.

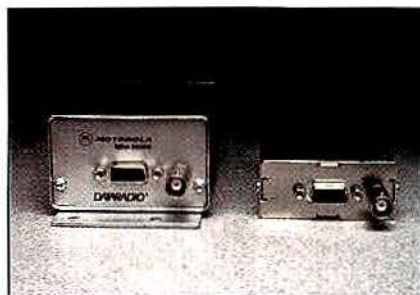
Handling binary data at speeds as fast as 9,600bps, the modem incorporates

logic and modem circuitry, based on Dataradio's proprietary modem chip, which was then coupled with a Motorola transceiver to make the final product. The low idle-state current consumption of the unit, 35mA, is one of the reasons the modem was selected for the Mars mission.

Two modem units are actually being used on the Mars surface, one in the Rover, the other in the Lander. They transmit telemetry, control and status in-

The low idle-state current consumption of the modem, 35mA, is one of the reasons it was selected for the Mars mission.

formation between the two mission vehicles over a range of about 500m. The 2W terrestrial version of the modem covers a range of about 50km. Two UHF whip antennas carry the signals. The center frequency for the transmissions is 459.7MHz, with a 25kHz bandwidth.



The "terrestrial" version of the 9,600bps modem sent to Mars.

The only modifications for the Mars application were the addition of heating units to withstand temperatures as low as -110°C, and replacement of some plastic connectors with hardwired connections to withstand the unique "bump and run" balloon-assisted landing that was executed by the lander.

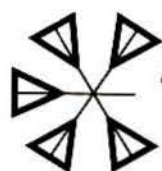
Meanwhile, back on Earth...

For more "down-to-earth" applications, Dataradio has produced units for public safety mobile computing and for systems control and data acquisition (SCADA).

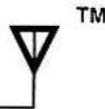
Two formats for vehicular information systems, designated PS2000 and PS2001, include NLETS/NCIC database access, status indication, free-form messaging and email. The PS2000 version provides a set of pre-formatted inquiry forms allowing field officers to check license tag, driver ID and stolen vehicle information. An alert feature provides a warning notice for officer attention. The terminal software enables communications with both the base and other mobile units via private digital communications. The PS2001 version is based on a scalable message switch and provides terminal emulation that allows portable computers to be used in place of mobile data terminals (MDTs), with either keyboard or pen-based operation.

Forms can be selected by function keys or a drop-down menu. The messaging features include individual, group or all-call capability. The systems are network-ready for "mug shot" or fingerprint transmission and also provide messaging capability for the Internet. There is also an optional field-reporting system.

The public safety systems include frequency coordination and licensing services, as well as traffic analysis and a radio coverage study to ensure performance. All hardware, including mobile and base



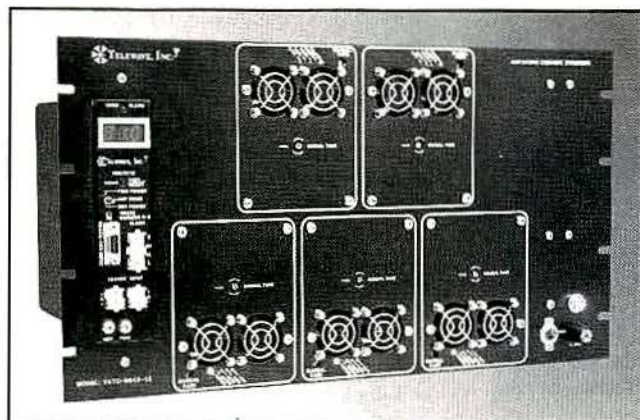
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Telewave Antenna Power Dividers are unique in the industry! Frequency ranges from 30-2000 MHz, 500 watt power handling, and nearly zero loss. 2, 3, and 4-way splits available, with TXYLAN™ coating and all brass construction.

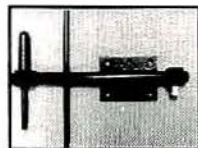
*ANTPD21*

Telewave Yagi Antennas now cover 138-2000 MHz and feature 3 different cable attachment and mounting options, as well as fully welded construction and exclusive TXYLAN™ coating.

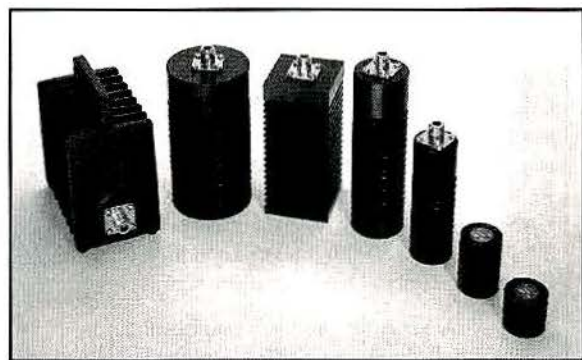
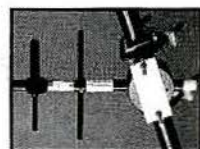
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radios, mobile computer and mounts, antennas and other components are provided with a detailed design and implementation plan.

Linking mobile uses to SCADA

Dataradio's Integra modem system allows both fixed SCADA and integration of SCADA into mobile data networks. Four configurations include fixed point-to-point SCADA/telemetry, a wide-area

network for SCADA/telemetry, combined mobile data and SCADA, or wide-area mobile data and SCADA. In a full channel, transparent mode, the modem is capable of passing data at speeds as fast as 9,600bps (8,000bps on a half-channel system). For data collection platforms incapable of RTS/CTS handshaking, the modem has a data-detect feature that initiates the transmission.

The modem avoids packet collisions by

dynamically allocating channel resources. "Listening" before transmitting allows the modem to use 70% of a channel.

Extending networks with ISDN

Intraplex, Westford, MA, has produced a series of multiplexers, designated Intralink, that allow mobile radio operators to use integrated services digital network (ISDN) circuits to extend their networks. It has also created the Securelink multiplexer line designed specifically for agencies using the federal government's Securenet for transmission of encrypted voice traffic. Both products provide for transmission of voice, data, audio, graphics and video information.

The use of digital ISDN services provides a supplement to the combination of analog microwave and high-capacity T1 lines carrying traffic between dispatch and transmission towers for EMS, police and fire operations. As many as four clear or encrypted full-duplex channels can be supported on two B-ISDN circuits, which can be routed independently to separate locations.

Can you keep a secret?

Encryption technology formerly restricted to military applications, is now available for safeguarding public safety, commercial and industrial data. Harris, Rochester, NY, provides a communications security terminal (CST) designed to secure voice, fax and data traffic across a range of communications media, including radio and cellular networks. The CST automatically generates session keys and can be operated without any user configuration. User-specific encryption keys can be inserted and altered using a smart card that can be programmed on a PC using Harris-supplied software. A single terminal can be used in several secure networks. The terminal can serve in a stand-alone secure mode, or it can be connected to an installed PABX to provide security for an entire local network.

Using data networks for messaging

Ardis, Lincolnshire, IL, has announced the availability of email and two-way messaging applications for the Microsoft Windows CE operating system on its nationwide data network. Designed for hand-held PCs offered by several manufacturers, the Windows CE system can be linked by a Motorola PM100D wireless modem card to create a mobile messaging system with links to Windows-based desktops, the Internet or intranets. The Ardis system currently is deployed in more than 400 metropolitan areas in the United States, with more than 80% population coverage.

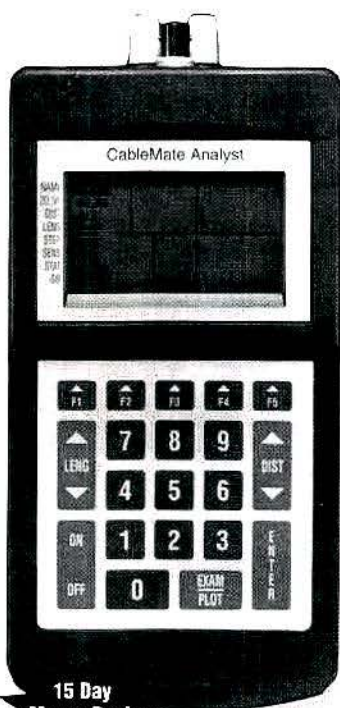


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The **AEA CableMate™** graphical Time Domain Reflectometer (TDR) is packaged in the same style package as the SWR analyzers. The CableMate shows multiple faults in a cable on the graphical display. Virtually any multi-conductor cable may be tested for shorts, opens or impedance lumps. The CableMate is an excellent device for measuring the length of most any cable for inventory purposes. It will also directly show the 25 MHz return loss. An RJ-45 switch adapter allows easy testing of LAN cables. The CableMate is priced at \$299.95 plus \$7.50 shipping and handling for a limited time only. One year repair warranty.

All AEA analyzer products come standard with a serial computer interface. Optional applications software with interface cable is \$29.95 each. With this software you can store the graphical data for your antennas or cables for future reference.



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Technically speaking

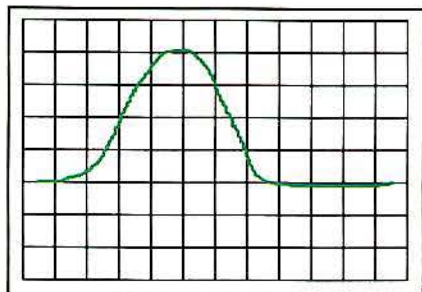


Figure 6. Typical response curve of bandpass filter.

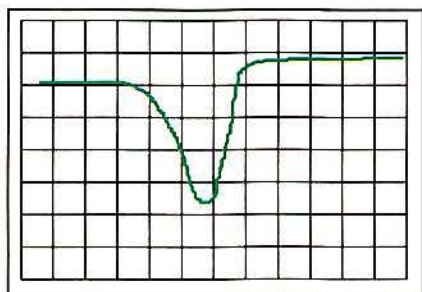


Figure 7. Typical frequency response of notch filter.

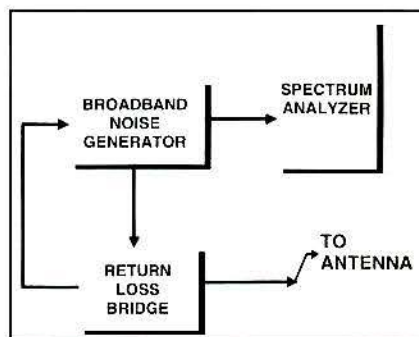


Figure 8. This setup is used to check the resonant frequency or bandwidth of an antenna.

(continued from page 8)

antenna. A return loss bridge such as one shown in Photo 2 on page 60 would be appropriate for this test setup. The chart shown in Table 1 on page 60 converts return loss to VSWR. The antenna is connected to the DUT port of the return loss bridge. With the spectrum analyzer set up to sweep the appropriate frequency span, the resonant frequency of the antenna will appear as a null in the display, as shown in Figure 9 on page 60. The minimum amplitude represents the resonant frequency. Note the amplitude at the null, then remove the antenna and leave the

DUT port open. Note the new amplitude at the resonant frequency. The difference between this amplitude and the amplitude of the display with the antenna connected is equal to the return loss of the antenna at the resonant frequency. For example, if the difference is 20dB, then the return loss is 20dB and the VSWR is 1.22, according to Table 1. The operating bandwidth of the antenna can be easily determined from the display. For example, if the maximum allowable VSWR is to be 1.5:1, then check the frequencies (minimum and maximum) where the return loss is 14dB.

Another use of the noise bridge is to check the operation or tuning of an *isola-*

tor. The setup shown in Figure 10 on page 61 is used for checking the response of an isolator. Note that the output of the noise generator is fed to port 2, or output port, of the isolator. With the proper frequency span on the spectrum analyzer, the frequency response of the isolator will be displayed. The null should be located at the desired operating frequency. If not, the isolator can be tuned to the desired operating frequency as long as the desired frequency is not too far away from the frequency for which the isolator was designed. To get a reference mark, the noise

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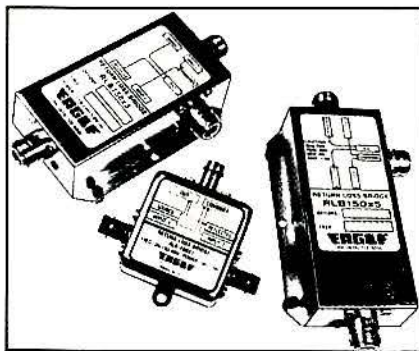


Photo 2. Typical return loss bridges for the test setup shown in Figure 8. Photo courtesy of Eagle, Sedona, AZ.

generator switch can be switched to bypass the DUT. The difference between the reference mark and the null amplitude is equal to the isolation of the isolator in decibels.

The frequency response of the narrow bandpass filters in a receiver can be checked as shown in Figure 11 on page 61. Note that a probe is used to sample the low IF output beyond the bandpass filter(s). The probe is connected to the "RETURN FROM DUT" port on the noise generator. Since the RF front end and high

Table 1. Conversion of return loss to VSWR.

| RETURN LOSS (dB) | VSWR |
|------------------|------|
| 9 | 2.1 |
| 10 | 1.92 |
| 11 | 1.78 |
| 12 | 1.67 |
| 13 | 1.58 |
| 14 | 1.5 |
| 15 | 1.43 |
| 16 | 1.38 |
| 17 | 1.33 |
| 18 | 1.29 |
| 19 | 1.25 |
| 20 | 1.22 |

IF sections of the receiver are wide compared to the low IF section, the overall response curve represents the low IF filters.

Summing up

The BNG-1000A noise generator can be used to check the frequency response on almost any frequency-sensitive device. The results you get will depend somewhat on the quality of spectrum analyzer you use with the device. Some of the low-end spectrum displays on service monitors are not satisfactory for this purpose. Others

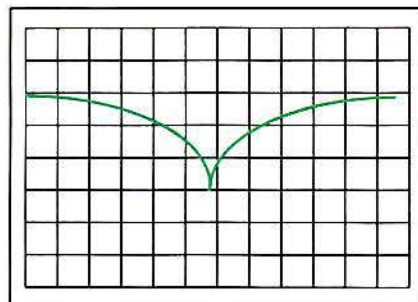
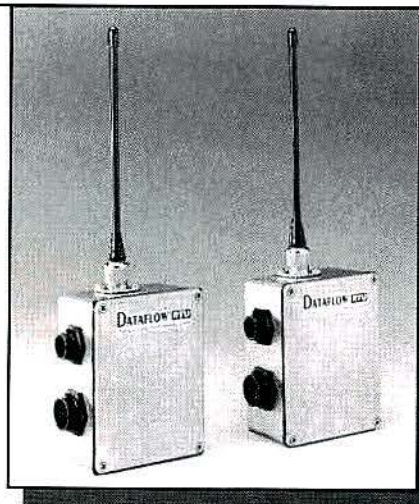


Figure 9. Typical display of antenna return loss using return loss bridge/noise bridge.

are well-suited to the task.

Remember to keep the sweep rate down to prevent distorting the waveform. Slow sweep rates are best for getting the most accurate representation of the frequency vs. amplitude response on the spectrum analyzer display. This may cause a bit of a problem when trying to tune to a peak or a null. If the sweep rate is too slow, the display won't follow the tuning fast enough for real-time response. In this case you may have to speed up the sweep rate and set the notch or peak to the correct frequency, and then reduce the sweep rate to check for the accuracy of tuning. It may



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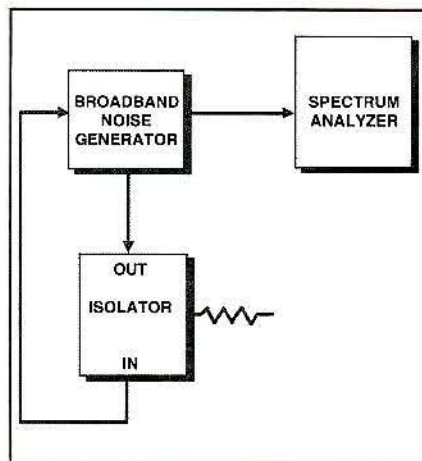


Figure 10. This setup is used to check the frequency response of an isolator.

be necessary to go back and forth several times to get the peak or null at the correct frequency.

If your spectrum analyzer has a manual sweep feature, use it to set the spectrum analyzer to the desired peak or null frequency and tune the device for maximum or minimum amplitude of the dot on the screen. Then recheck the re-

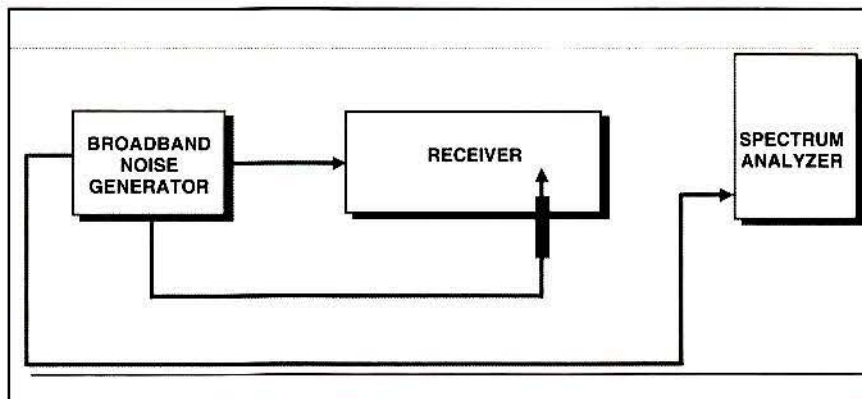


Figure 11. This setup can be used to check the narrow bandpass filter response in a receiver. A low-capacitance scope probe can be used.

sponse curve using a slow sweep rate again.

Although the BNG-1000A broadband noise generator can't beat the tracking generator and spectrum analyzer combination, it definitely has its place in the two-way shop. The simplicity of operation and portability would certainly enhance its use in the field as well.

For further information on the BNG-1000A broadband noise generator contact:

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Until next time—stay tuned!



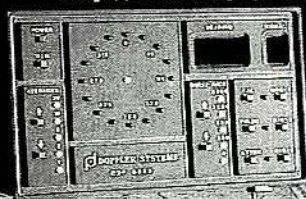
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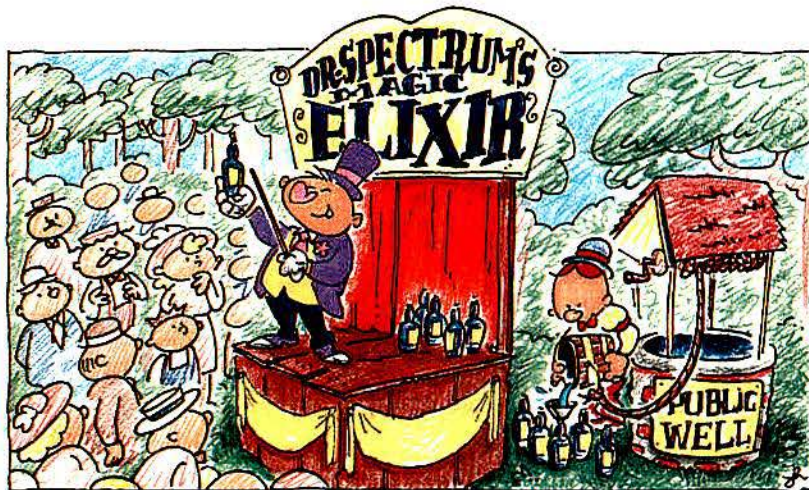
By Robert H. Schwaninger Jr.

Every year about this time (it's around Independence Day when this is being written), I think about being a citizen of these United States. It's a notion that's less popular these days. Seems like everyone is trying to force me to join up as a card-carrying globalist. But, to be honest, I just can't do it.

You see, as corny as it sounds, I love being an American. I stand at baseball games and sing the National Anthem, and I know all the words. When I see someone in uniform, I feel proud. When I walk up the steps on Capitol Hill, I still feel like I'm ascending into a higher place, where freedom and justice still stand as our greatest objectives. Even living here in Washington, I am still moved at the sight of the Lincoln Memorial and the Washington Monument.

I think that voting is the greatest act I can contribute as a regular Joe. I read the newspaper to assure that I am informed, and I get as disgusted as everyone else about the shenanigans that go on that have nothing to do with keeping our country safe and free and blessed with the spirit

Schwaninger, MRT's regulatory consultant, is a partner in the law firm of Brown and Schwaninger, Washington, DC. He is a member of the Radio Club of America.



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that makes us what we are. It's what we are, and the notion of what we could be, that I seek to preserve. You see, I'm a little old-fashioned that way.

What we *are* is the most beautiful and sometimes silly mix of stuff that any nation ever visited upon this sometimes crazy planet. We are the inventors of poker, a game that perfectly blends skill and chance into a balance of bravado rarely enjoyed in

any other pursuit. Americans invented the blues and jazz, saucy blends of tempo and abandon that are both as sad and as introspective as they are irreverent and care-free. The United States' contributions to literature include the cowboy sagas, Mark Twain novels and Horatio Alger stories, giving dreams and hopes of adventure and wealth to generations.

We produced the robber barons: Astor, Carnegie and Rockefeller; then sent the union men, like Gompers, to keep them in check. Our industry has built the empire of IBM, but still found room for Apple. Americans cheered on Babe Ruth for his bat and Jackie Robinson for his bravery, noting the different kind of heroics in each. We have fought conflicts that left us wondering whether war was ever a civilized option, and we have fought when no other option was viable. The humor of the battlefield has borne the fruit of freedom across the globe.

Even our hatreds are truly American. We hate monarchs and people who put on aristocratic airs. We hate intrusion into our freedoms, when someone tries to force us to do what they think is right. We loathe taxes, because taxes mean that someone else is controlling our purse strings. We chafe at regulation because it reduces our options and puts barriers around our ability to produce at will. We don't like cheats, influence peddlers, back-room deals, insider trading, bushwhackers, elitists, bigots, snobs, liars and people who tell us we're either too ignorant or too

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unsophisticated to understand.

Yes, there is something wonderfully unique about being an American—one of a strange group of folks that love the flag and frown at the government that sometimes forgets who that flag represents. Old Glory represents people who seek an unfettered opportunity to live and grow and thrive as each sees fit. As the old pledge goes, "One nation under God, indivisible, with liberty and justice for all."

Given that the freethinking people of this nation fiercely defend and worship their independence and freedom, how is it that the message isn't getting to Washington? How is it that we have created a class of elected representatives that often forget the very spirit of the people they are charged to represent? Instead, we are treated to a form of elitism that is as uncharacteristic of our heritage as the crowning of kings.

Property qualifications for voting were dropped after 1812. Since then, when have we allowed a requirement that a person must be wealthy or they can be wholly excluded from the rewards of citizenship? Isn't that what spectrum auctions do? In their barest form, auctions reward wealth above industry and financial elitism above sincerity. They take the freedom of opportunity and put it on the block, selling it one channel at a time.

*Auctions ... take the
freedom of opportunity
and put it on the
block, selling it one
channel at a time.*

Perhaps the tendency of lawmakers who are pressing the auction agenda forward is understandable. After all, Americans are impatient people, and impatience with attempts to balance the nation's federal budget problems is likely at the core of this activity. But shouldn't this impatience be tempered with the desire to do the right thing?

There's also a bit of Hollywood (another American institution) in all this. Problems are often thought to be solvable in the space of a three-reeler, and anyone that takes longer than that is deemed ineffective. Politicians, constantly running for reelection, need some alleged victory to tout their worthiness. Meanwhile, they raise money—tons of money—to finance their endless campaigns that feature the media blitz, the attack ad and the talking head. Corporations, PACs and the monied

classes learned long ago the value of the political contribution.

This summer, we are witnessing the sale of MCI, a company that took on the powers-that-be simply to exist. It's going to British Telecom. This is not the first or last time for entry by foreign companies into the U.S. telecommunications industry. The examples are numerous and growing. Each time a merger or buyout occurs, lawmakers and regulators will be required

to pass judgment on whether each new mega-deal is good for our economy. They will most likely acquiesce to every request.

You see, despite what you may read or hear about the antics of John Huang and his Chinese supporters, foreign money in the form of campaign contributions (usually laundered through American interests) passes into the hands of campaign coffers like a steady stream. A \$50,000 check to spend a night in the White House is peanuts



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compared to the vast amounts of money being spent all over the United States to urge a vote here or there. If Huang is guilty of anything, it's his arrogance in not professionally dry-cleaning the boodle first.

Sen. Fred Thompson's (R-TN) committee is staring at a moth hole, while the entire fabric of our republican form of government is unraveling before us. Isn't it obvious to Congress why the American public is unconcerned about these hearings? The electorate already believes that everything is for sale in Washington—including votes. Why should they believe otherwise? They have no evidence to the contrary. Spectrum auctions merely confirm the "red-tag sale" impression of government.

But we, as Americans, still have hope. That's another great feature that we possess. The future always looks bright to us, even when everything is looking pretty bleak right now.

We hope that Sen. John McCain (R-AZ) will see the light and get us off of this 100-mph auction merry-go-round. We hope that the next group of FCC commissioners has some knowledge of the industry and not just the politics surrounding it and stifling it. We hope that someday Vice President Al Gore will shut up about the "information superhighway" and start talking about *people*, like the little two-way shop operators who are just trying to get ahead.

Every year I take time out to think about

the fabric of our great nation, about from where we've come and where we might arrive. I think about the virtues admired in our presidents: Lincoln's honesty, Washington's bravery, Jefferson's vision and Truman's common sense. Our nation's anthem was penned during the bombardment of Fort McHenry, when British forces were beating on the door and Francis Scott Key considered our opportunities for victory. It was a perilous time for our young nation, but we prevailed and launched the greatest republic that the world has ever seen because we believed. I still believe—and my beliefs are not for sale at public auction.





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PCIA fights CMRS mobile service fees on two-way paging services

In the FCC regulatory fee Report and Order issued in June, the PCIA successfully persuaded the FCC to categorize two-way paging services under its commercial mobile radio services (CMRS) one-way paging regulatory fee category, and not under its CMRS mobile services category.

In their comments, PCIA and member companies Paging Network and Arch Communications Group each argued that a two-

way pager is more similar to a one-way pager than the more general CMRS mobile services, which includes broadband two-way interactive voice communications.

"The commission's ruling dramatically reduces regulatory fees imposed on two-way paging carriers, from 24 cents to 3 cents per unit," said Rob Hoggarth, PCIA's senior vice president, paging and narrowband PCS. "This will significantly

aid in the nationwide deployment of narrowband PCS, as well as increase the number of telecommunications choices offered to consumers."

Hoggarth added, however, that, "Our battle to roll back fee hikes continues. The commission's order failed to justify fee increases across the board. We intend to challenge the order on that basis for all members of the wireless industry."

SBT seminar focuses on FCC rules, spectrum, and technology issues

Opposition to 800MHz auctions, allocation of recaptured UHF TV spectrum and interference issues were topics at Small Business in Telecommunications' June seminar. The regional seminar, held in St. Louis, was attended by about 75 individuals representing 50 companies.

Mike Hamra, legal advisor for the FCC's Wireless Telecommunications Bureau, discussed proposed SMR partitioning and disaggregation rules for 800MHz. Discussion with attendees covered SBT's opposition to auctions and the likelihood that SBT will support any court challenge to 800MHz auctions.

Regarding allocation of spectrum from TV channels 60-69 (746MHz-806MHz), SBT has urged the FCC to reduce geographic licensing to areas no larger than a Basic Economic Area (BEA). As explained at the seminar, this would reduce inherent market-entry barriers to small business.

Association counsel Dennis C. Brown reviewed the FCC reforming docket and discussed co-channel interference from digital systems experienced by analog operators.

Association counsel Robert H. Schwaninger Jr. discussed SBT's filing of separate reply comments in the FCC reforming docket and in the FCC rulemaking on future protection of 220MHz incumbent licensees. SBT has opposed new restrictions on UHF trunking and requested greater protection for 220MHz systems.

Jerry Ulcek, of the FCC's Office of Engineering and Technology (OET) discussed updates to RF emissions and human exposure guidelines.

The two-day program included technical presentations by two of the association's industry sponsors, E.F. Johnson and Standard Communications, on repeater and trunking technology.

SBT Executive Director Steve Eldridge said the association will hold a legislative forum in Washington, DC, Oct. 27-28 which will include presentations from federal policymakers.

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PCIA revises Telocator Data protocol (TDP) suite of protocols for both one-way, two-way paging

Technicians who troubleshoot paging systems may find datascope analysis of network problems easier as version 3.0 of the Telocator Data Protocol (TDP) is adopted by manufacturers. Released on July 8 by the Personal Communications Industry Association (PCIA), Alexandria, VA, the suite of protocols is an open systems standard that supports both one-way (traditional paging) and two-way

(narrowband personal communications service or NPCS) paging.

"Most paging infrastructure products use Telocator Alphanumeric Protocol (TAP) as an entry method for digital information," said Ralph Tomeoni, chairman of the TDP committee and president of TekNow, Phoenix. "TDP is to replace TAP."

Tomeoni explained that the committee

had identified 50 varieties of TAP. The protocol was loosely developed, and implementations differ, a fact that has inhibited major software vendors from adapting their applications for wireless use. "For example," Tomeoni said, "Lotus Notes has a gateway that uses TAP, but it only works on certain systems." TAP was developed 15 years ago as a basic protocol, and it has gone off in different directions, he explained.

In contrast, TDP uses standard protocol layers defined by the American National Standards Institute (ANSI) and the International Standards Organization (ISO).

"When you are troubleshooting an infrastructure product that uses a standard protocol, a datascope across the line makes troubleshooting easier," Tomeoni said. "With equipment that uses a TAP program, when a technician tries to 'scope all the information across line to see why it is not handling the protocol correctly, he has to know the ins and outs of many variations to try to adjust the equipment to fix the problem." With TDP, every manufacturer follows the same standard, which simplifies interpreting the datascope display. Technicians can work on a single understanding of the protocol to work on every company's equipment.

The TDP suite has five protocols:

Telocator Message Entry (TME) is used with wireline entry devices to send information to the paging company. It converts binary codes to codes compatible with existing paging systems.

Telocator Format Conversion (TFC) converts 8-bit computer data to the 7-bit data used by most paging systems.

Telocator Radio Transport (TRT) breaks the 7-bit data into small packets.

Telocator Mobile Computer (TMC) defines how a wireless PC card transfers information between the card and the computer so the computer can download information from the wireless device.

Wireless Message Format (WMF) allows applications at the sending or receiving end to communicate, regardless of the system between them.

The TDP suite is intended to work not only with paging systems, but with narrowband personal communications service, wideband PCS and equipment used by RAM Mobile Data, Ardis and Nextel.

"Version 3.0 represents a major milestone for PCIA and wireless messaging," said Tomeoni. "By reaching a consensus on this broad standard, the leaders in wireless messaging have set the course for the industry's future."

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Circle (64) on Fast Fact Card

New technology recharges batteries in five minutes, no overheating

If there is one complaint mobile radio or cellular phone users have, it is the time it takes to recharge the battery. In most applications, batteries require from one hour to overnight to be fully recharged. However, this may be changing. Advanced Charger Technology (ACT), Norcross, GA, has demonstrated a new technology that fully charges cellular phone batteries in five minutes without overheating.

ACT's Ultra-Rapid is based on a process known as dynamic electrochemical waveform (DEW). Using an imbedded microprocessor, the system monitors how well charged particles in the battery move during the recharge process. As the battery increases its charge, this movement changes. DEW adjusts the recharge waveform to accommodate this change, and by employing conventional and proprietary means, the system determines when the battery is fully charged. This eliminates "cooking" (overheating) the battery, which can shorten battery life. Yuri Prodrzhansky, a Russian engineer, invented the technology because he was frustrated by having to throw away so many batteries from his son's toys.

Because overheating can degrade battery life, DEW has demonstrated it can extend battery life. In a series of independent tests DEW was evaluated on nickel metal hydride (NiMH) batteries and nickel cadmium two-way radio batteries. At the University of Pittsburgh Battery Research Center, NiMH computer batteries were fully charged in less than 26 minutes and battery life was evaluated at as much as three times normal.

Conventional NiMH charging typically takes between one to three hours. The nickel cadmium batteries were tested by the Naval Surface Warfare Center and showed similar results.

Although the five-minute charger is not yet available to the consumer, ACT is producing a two-way radio charger that can recharge a battery in as little as 16 minutes. The five-minute capability is expected to be available later this year. ACT is also developing a charger for cellular phones that is similar to the 16-minute two-way radio charger. It, too, will be available by the end of 1997.

PageTap to develop Motorola paging receiver engines

PageTap, Denver, has signed an agreement with Motorola, Schaumburg, IL, to be an OEM developer for the DataLink family of paging receiver engines, the latest technologies from Motorola.

PageMart Wireless to carry Philips' Cobalt numeric pager

PageMart Wireless, Dallas, has entered into an agreement with Philips Consumer Communications, Irving, TX, to carry Philips' Cobalt numeric pager.

The numeric pager now accompanies PageMart's Motorola and Uniden lines of pagers. Offering distinct paging designs, Philips' Cobalt pager features capabilities

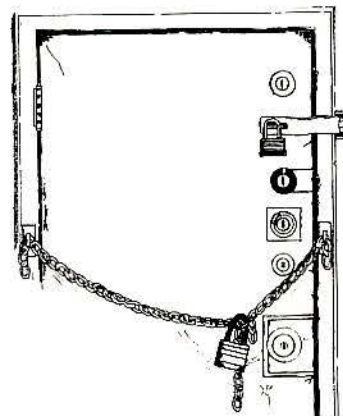
such as three-button interface, large backlit display screen with 20-digit message, 12-digit display and 32-message memory; selective message deletion, 20 protected messages, silent vibration options, nine user-selectable audible alerts, time and date display, alarm features, low battery alert and a 25-week battery life.



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Readers' choice

Of all the new products and services in the February 1997 issue, the one reprinted here generated the most reader requests for additional information. If you missed it the first time, here is your opportunity to acquire more information on it. Just circle the corresponding Fast Fact Card number on the card found in the back of this issue and mail the card to us.

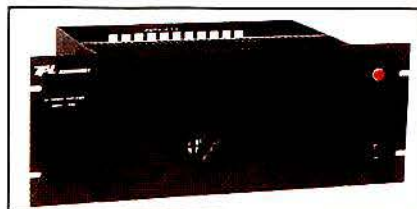
AVL-dispatch system supports fleet management

The Trakit AVL system for vehicle fleets combines business radio and Global Positioning System (GPS) technologies. The application from the MD/GPS division of **IDA** tracks and displays vehicle locations on a Microsoft Windows 95-based computer at the dispatch center in real time on supplied screen maps. Vehicle activity can be replayed for efficiency analysis or exported to cost or billing applications. The system is designed for 220MHz, 450MHz, 800MHz, shared or dedicated, trunked or conventional radio systems. The GPS receiver and location transmitter box can be placed anywhere in the fleet vehicle.



Circle (500) on Fast Fact Card

Continuous-duty power amp installs in closed cabinet



The RXR series base station and repeater power amplifier from **TPL Communications** can be configured with any TPL amplifier from low band through 960MHz. For power levels greater than 120W, an optional cooling fan can be installed. Standard configurations are 800MHz and 900MHz amplifiers at 80W and higher with a cooling fan. Both configurations have flat front panels that allow for cabinet installation, leaving sufficient room for airflow with the door closed. The amplifier has a circuit breaker and an on-off switch located on the front panel. It can be supplied with or without a dc power supply.

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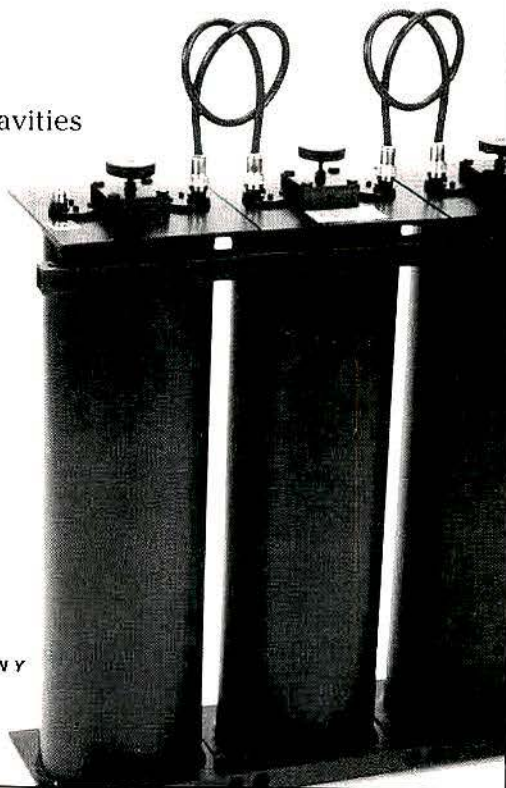
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Circle (66) on Fast Fact Card

Repeater maker features built-in four-user CTCSS tone panel



CES Wireless Technologies has developed an enhanced version of the Repeater Maker, the Repeater Maker Plus, model RM-20. This device allows users to make a repeater out of two transceivers or separate transmitter and receiver modules. The RM-20 provides a built-in, four-user CTCSS tone panel, supporting any four of 50 CTCSS tones as well as cross-tone encoding. Standard features include "Morse code" CWID with programmable "send" states and an "auxiliary relay" for remote control. The RM-20 is programmed using a touch-tone telephone locally or remotely over the air. The unit accepts the optional CES voice delay module for customization of application timing. The RM-20 features compact, metal housing and is "plug and play" compatible with the CES 4700VP telephone interconnect.

Circle (302) on Fast Fact Card

Coupler combines two-way monitoring with lightning protection

M/A-COM's low-loss, high-power, dual-directional coupler with lightning protection is for PCS base stations. It enables accurate directional monitoring of cell-site transmit and receive signals by using two separate secondary lines, each sampling at 1/1000 of the power (230dB) transmitted. The lightning protection circuitry is designed to be permanent and to withstand large strikes without a need for element replacement. M/A-COM's CH20-0039-30 coupler provides power sampling of both transmitted and reflected power. The coupler operates over the full PCS transmit-and-receive bandwidth of 1,850MHz-1,990MHz. It is suited for installation between the antenna cable and base station within a base station enclosure. The coupler's integrated lightning protection circuit protects against the harmful current accompanying a tower or antenna cable lightning strike. Stainless steel grounding hardware accommodates NEMA spaced ground straps. The appropriate plating and absence of any ferrous material in the circuitry is designed to minimize intermodulation products. Air line construction yields the low insertion loss and VSWR, allowing dual-directional monitoring without sacrificing base station performance.

Circle (303) on Fast Fact Card

Station supplies dc power for portable field instruments



The Berkeley Varitronics Systems power station supplies dc power for field instruments. The power station produces an output of a nominal 24V dc for 10 hours of continual use. The unit has a self-contained charger that will recharge its internal battery source from any standard 110Vac outlet overnight, leaving it ready for a full day of testing by morning. The power station has two sets of wheels, one for indoor use and one for more rugged outdoor use.

Circle (304) on Fast Fact Card

Terrain elevation database allows fast access to data

EDX Engineering's terrain elevation database is for use by those in communications engineering. This worldwide database was derived from the GTOPO30 Project of the USGS EROS data. These data points have a horizontal grid spacing of 30 arc seconds. Individual 5°×5° blocks are available. Ocean blocks containing no land are excluded. Antarctica is also excluded. The EDX format allows

rapid access to the data from EDX's radio propagation prediction software programs. The 30-second data integrates with EDX's other terrain data to form a hierarchy of databases that can be used to perform signal studies. The database is supplied in EDX format with a free conversion program for those who want an ASCII format.

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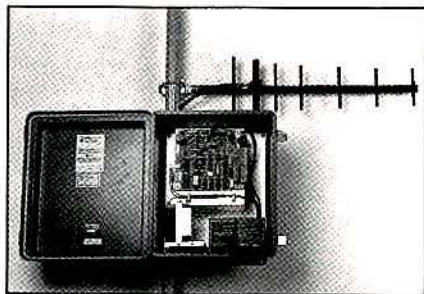
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Circle (68) on Fast Fact Card

New products

Unlicensed spread-spectrum telemetry unit works as wireless 'line-of-sight' conduit



Zetron's Control Link+ model 1804 spread-spectrum telemetry units eliminate the cost of dedicated wiring and conduit or the recurring expense of leased circuits. Each unit functions

like wireless conduit, instantly transferring as many as 16 contact and eight analog inputs to corresponding outputs over line-of-sight distances of as far as 15 miles. Control Link+ can operate between two points or in multipoint configurations. The unit is for applications such as freshwater and wastewater, oil and gas production and pipelines, electrical power grids, plant security, industrial processes and traffic sign management. Control Link+ includes process interface inputs and outputs, a 902MHz-928MHz spread-spectrum radio, a yagi directional antenna, a NEMA 4X enclosure, a line power supply, a back-up battery and a charger. No radio license is required.

Circle (306) on Fast Fact Card

Amplifier system provides transmission in tunnels



Tunnel Radio of America's DAS800 is a bi directional amplifier system providing two-way radio transmission in tunnels and other difficult coverage environments in the

800MHz-900MHz bands. This technology provides amplified bandwidth space for as many as 32 repeated channels and an additional 12 video channels. This system will work with any signal format, providing a pure RF path. The output power per amplifier variable from 1W to 3W provides possible lateral coverage from the antenna system up to 5,000 feet. The amplifiers incorporate diagnostic reporting capability. Both cellular and 800MHz radio coverage systems are available. Active components are powered through the single cable antenna system providing a low component count.

Circle (307) on Fast Fact Card

Mounting system promotes safe operation of phones

The passive holding device, the PHD 501, from Pro-fit International, creates a mounting system for the Motorola Micro-Tac phones. The device contains no buttons or latches. Simply slide the phone in and tilt it back to secure. To remove, tilt forward and slide out. The power cord can remain attached to the phone or may be unplugged and placed in the built-in notch for safekeeping. The Pro-fit system is designed to encourage safer vehicle operation by positioning the phone only a glance away from the road.



Circle (308) on Fast Fact Card

Spread-spectrum modems immune to interference

The WinCom 900 distributed by World Communications Group are spread-spectrum radio modules that permit a wireless link to computers, peripherals or other devices equipped with an RS-232, V.35 or RS-422 port. Typical wireless applications include wireless LAN, remote data collection, real-time inventory control, environmental monitoring, security and alarm links, electronic retailing and point-of-sales, manufacturing automation, point-to-point and point-to-multipoint data links and Internet and intranet. Using the spread-spectrum technology, the modules provide interference-immune operation through walls, floors and other obstructions. Versatile two-way transmission of data, voice and image makes it suitable for private lease line replacement. The connectors are fully Hayes-AT compatible and support most commercially available communication software packages such as Procomm, PC-Anywhere or Xtalk.

Circle (309) on Fast Fact Card

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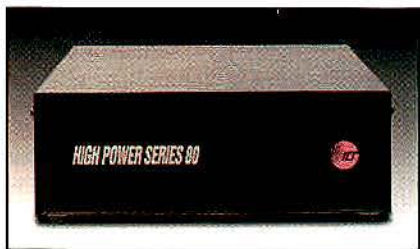


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Circle (42) on Fast Fact Card

Switching power supplies offer continuous current



ICT's High Power series of switching power supplies are available in 40A, 60A and 80A models. They have a wide input voltage range of 90Vac–270Vac at 50Hz–60Hz, with a diode-protected output. Additional features are power factor correction, internal voltage control and an input switch and circuit breaker. ICT High Power series units are available in standard desktop, rack-mount, LCD meter and rack-mount with meter configurations. Wall-mount brackets are included with all non-rack-mount models.

Circle (310) on Fast Fact Card

Downtilt technology added to trunking antenna

The ASPA977HV5E from the *Decibel Products Division of Allen Telecom* is an omnidirectional antenna for the 800MHz trunking market that offers adjustable electrical downtilt resulting from Vari-Tilt technology. By moving a lever on the side of the antenna, the system designer can create 0° to 5° of downtilt in 1° increments, thereby focusing the antenna's signal precisely in the designated area. The antenna provides 8.5dBd of gain in the 806MHz–869MHz range. It can handle continuous input power to 750W and is built to operate in winds as high as 125mph.

Circle (311) on Fast Fact Card

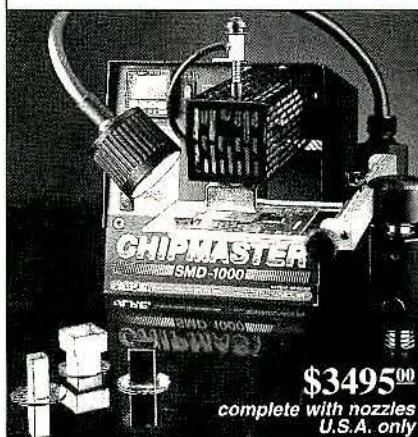
CDMA test software simplifies mobile phone tests

Noise Com's CDMA automated test software (CATS-98A) is for total testing of mobile receivers and transmitters as specified in IS-98A. The CATS-98A program integrates Noise Com's wireless impairment system (WIS-98A) and a base station simulator. The software simplifies complex mobile phone tests including demodulation under additive white Gaussian noise (AWGN) and multipath fading conditions, and single tone desensitization and intermodulation distortion in the presence of interference signals. Based on Windows NT and C++, the program architecture is flexible and modular, making it simple to add new test modules and upgrades. The program controls each instrument in the WIS test system via the GPIB interface. It permits calibration to include consideration of RF cable losses in the test system.

Circle (312) on Fast Fact Card



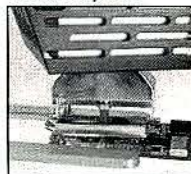
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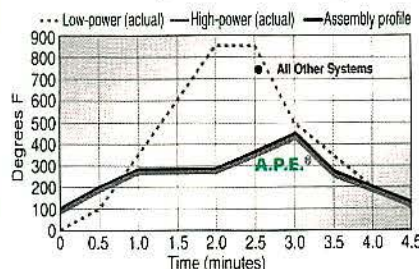
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Circle (70) on Fast Fact Card

New products

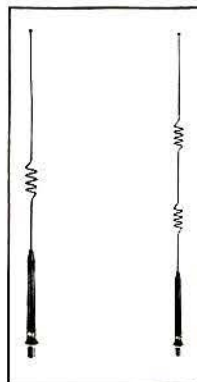
Digital trunking logic board offers expanded set of features

The ST-865IC SmarTrunk II digital trunking logic board from **SmarTrunk Systems** is compatible with the Icom IC-F3, F4, F30 and F40 portable radio models and IC-F1020 and F2020 mobile radio models. It offers an expanded set of features including channel banks for multiple site access, multiple PTT talk groups, multiple receive groups, positive radio kill, dialed number display, turbo speed dialing

and smart scanning for faster access in a busy system. The ST-865IC is compatible with existing SmarTrunk II logic boards and controllers and supports all standard SmarTrunk II features. It allows users to share a common pool of frequencies to place individual calls, group calls and telephone calls while providing a wide range of management features to the system operator.

Circle (313) on Fast Fact Card

ISM band wireless data antennas only need small ground plane



New end-fed antennas, models ASPG918 and ASPG919, from the **Antenna Specialists Division of Allen Telecom** are based on an elevated-feed design. The halfwave collinear array antennas require only a small ground plane or bulkhead mounting bracket for optimal

performance. The ASPG918 model provides 3dB gain for 902MHz-960MHz applications, while the ASPG919 offers 5dB gain for higher gain requirements in the 890MHz-960MHz range. Both antennas are suitable for wireless and mobile data network applications in corporate, medical, education and other campus environments.

Circle (314) on Fast Fact Card

Remote site monitor provides a 14.4kbs modem, voice synthesizer

The ProTek jr remote site monitor from **PageTek** provides a 14.4kbs V.32 modem with integrated voice synthesizer. It also provides improved lightning protection with self-resetting fuses and optional second and third RS-232 ports. The monitor features expanded status reports to voice and alphanumeric pagers and full ANSI terminal support. The monitor alerts upon a return-to-normal event. It has the ability to store, modify and download programming from a laptop.

Circle (315) on Fast Fact Card

Data terminal provides text-to-speech conversion, backlit LCD

Wireless Links' Acknowledger is a one-piece mobile data terminal with text-to-speech conversion. The Acknowledger includes an integrated wireless radio modem from Ericsson. Weighing 14.1 ounces, the terminal measures 6.5"×3.5"×1.2" and features a backlit LCD, a full QWERTY keyboard and an RS-232 port for expansion. A user can attach the terminal to a bar code reader, GPS terminal, printer or signature capture pad. Designed to meet the specific needs of the transportation, courier and field service industries, the terminal can be used as a portable device or in a vehicle-based docking station.

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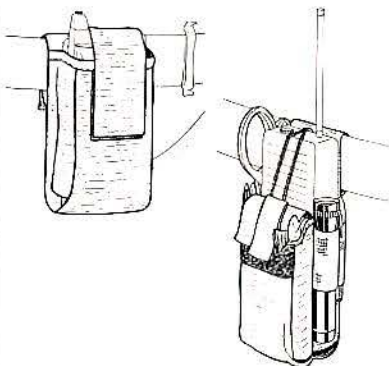
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New products

Mobile data communications system works as single provider

Dataradio's VISlink product line helps departments increase officer effectiveness, efficiency and safety in the field. VISlink offers a complete "system in a box" that includes all software, hardware and related engineering and implementation services. VISlink systems are based on Dataradio's vehicular information solutions (VIS) technology, which has been incorporated into more than 300 systems comprising more than 30,000 vehicles. VISlink packaged systems, PS2000 and PS2001, include NLETS and NCIC database access, status indication, free-form messaging and email.

The PS2000 provides a standard set of preformatted inquiry forms that enables officers in the field to quickly check tag, driver and stolen vehicle information for all drivers. A "hit alert" feature provides warning notices for officer attention. The PS2001 is for rapidly growing jurisdictions and is based on a technologically advanced, highly scalable message switch. PS2001 also provides terminal emulation that allows portable computers to be used in place of MDTs with either keyboard or pen-based operation.

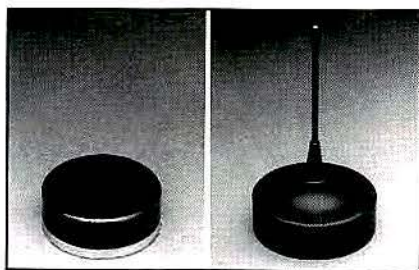
Circle (317) on Fast Fact Card

Programmable handhelds go narrowband, wideband

Uniden Private Radio Communications' hand-held radios have the ability to scan as many as 16 channels. The SPH51 and SPU51 are programmable for 12.5kHz and 15kHz narrowband or 25kHz and 30kHz wideband frequencies. The units come standard with a wall-charger adapter and are MIL-STD-810E-compliant. The radios have been designed to look and feel sleeker, round and comfortable in the hand.

Circle (318) on Fast Fact Card

GPS microstrip antennas offer tracking, positioning capabilities



The Hirschmann GPS antenna is a microstrip antenna with an active 26dB-gain, low-noise amplifier for the reception of GPS signals. The antenna integrates a GPS antenna patch and a GPS amplifier in one housing and mounts on the vehicle's rooftop through either bolting or magnetic configurations. This active antenna unit connects to a GPS receiver to access the satellite system that provides three-dimensional positioning and timing signals anywhere in the world. Used in conjunction with other support equipment, the GPS antenna supports such applications as vehicle tracking, navigation, emergency reporting, security, theft prevention, remote diagnosis, precision timing, interval measurement and synchronization. For cellular users, the Hirschmann GPS-cellular dualband antenna combines a microstrip antenna with a removable quarterwave whip for the cellular or SMR bands. The device consists of two independent antennas with a separate feed line for each band. This antenna offers the same tracking and positioning capabilities as the GPS antenna and can be used with either a cellular phone or SMR. Models include cellular coverage for the AMPS (North America) and GSM (European) bands. GPS coverage is centered on the L1 (civilian) band.

Circle (320) on Fast Fact Card

Measurement tool supports decoding for forward channels

A paging drive test and measurement system, the PageTracker Elite from Grayson Electronics Division of Allen Telecom is for the design, verification, optimization and maintenance of narrowband PCS paging networks. The system supports decoding for forward control channels for Motorola's Inflexion with reverse channel decoding available in the near future. Support for Reflex and Flex protocols is also coming. The Windows 95-based system runs on Grayson's modular mainframe, which supports single or multiple instrument grade receivers. Features include a real-time map that displays vehicle position as well as logging and playback of measurement parameters and messaging. It logs frame RSSI and BER and provides full message decoding on the forward control channel with reverse channel decoding available in a near-term release. PageTracker Elite also features a message window that displays all messaging on forward control channels for Inflexion. Future releases will have receiver site coverage mapping and a spectrum analyzer window available. The system uses an open log file format and internal and external GPS with dead reckoning.

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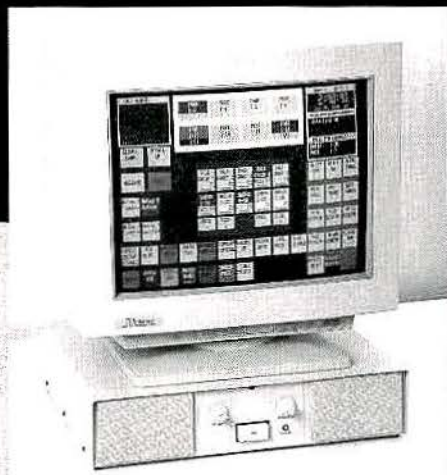
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One former and one current FCC employee are recipients of the Marconi Memorial Gold Medal of Achievement from the Veteran Wireless Operators Association, Fords, NJ. **Robert McNamara**, former chief of the FCC Wireless Telecommunications Bureau Private Wireless Division, is one of the recipients. McNamara is director of regulatory technology and compliance for Nextel Communications, McLean, VA. **Alexander Zimny**, director of the FCC Compliance and Information Bureau's New York office, is the other recipient.

Paul Parshley, vice president of Wayne Kerr, Woburn, MA, advances to worldwide managing director.

Mark Cockson, marketing and strategic business development manager at Centurion International, Lincoln, NE, advances to director of strategic business and market development.

David Distler departs Trilithic, Indianapolis, to join Bird Electronic, Franklin, IN, as midwestern sales manager.

Changes at Geotek Communications, Montvale, NJ, and its subsidiaries, Geotek USA (domestic operations), Geotek Technologies (manufacturing), Geotek International Networks (foreign operations) and a newly formed, yet-unnamed mobile data business unit:

Jonathan C. Crane, president of Geotek Communications, steps down as an officer and board member, becoming a consultant to the company. **Yaron Eitan**, chairman, takes on Crane's former responsibilities. **Robert A. Kerstein**, Pocket Communications' former chief financial officer, takes the same position with Geotek Communications. He replaces **Michael Carus** who held the position temporarily, and who resumes his role as vice president, corporate controller and chief accounting officer.

William A. Opet, senior vice president of the parent company, becomes president of the mobile data business unit.

Zvi Peled, once the president of Bogen Communications International, becomes president of Geotek Technologies.

Jon N. Peterson, C.P.A., departs Shared Technologies-Fairchild, Chantilly, VA, as vice president of finance to join Comsat RSI Plexsys Wireless Systems, Washington, DC, as vice president.

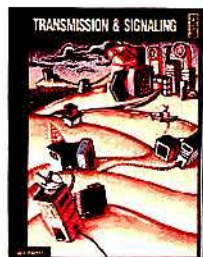
Thomas J. Langan, director of planning and profitability at Ram Mobile Data, Woodbridge, NJ, is promoted to vice president, wireless devices and systems.

Steve Aldinger, vice president of Celwave, Marlboro, NJ, is named to the Radio Club of America board of directors. Aldinger fills the remaining term of **Archibald C. Doty Jr.**, who resigned.

Brenda Maxfield, manager of media relations for the Personal Communications Industry Association, moves up to director of communications.



Book describes communications transmission and signaling



The book *Transmission and Signaling Basics* from **Intertec Publishing** delves into the science of communications transmission: how voice and data messages, analog and digital, are technically constructed

and how they change when sent from point A to point B. Opening with a definition of sound and data, the book continues with great detail on how messages change from voice to analog and text to digital. It includes discussions on the effects their transmission has on their structure. It covers everything from the basic fundamentals of sounds to baseband transmission. The book discusses digital transmission and the way it relates to fiber optics, satellites and other areas of telecom. It examines the latest in transmission technologies, SS7 architectures and their role in public networks.

Circle (351) on Fast Fact Card

Catalog includes coaxial products

Flexco Microwave's 1997 catalog is for commercial markets. It highlights Flexco's product applications as well as the application-based product lines. Products include: the SLL series (super low loss), the Performance series, the kW series, the S series (semi-flex seamless), Ultraflex small diameter cable and custom products.

Circle (352) on Fast Fact Card

Interim standards define conformance to Project 25

The Telecommunications Industry Association (TIA) has published two interim standards, "Project 25-DES Encryption Protocol," and "Conformance Test for the Project 25 DES Encryption Protocol-New Technology Standards Project-Digital Radio Technical Standards." The Association of Public-Safety Communications Officials-International (APCO), the National Association of State Telecommunications Directors (NASTD) and federal government agencies will be issuing common system standards for digital public safety radio communications (Project 25). TIA has generated standards, interim standards, specifications and telecommunications systems bulletins that define equipment and processes necessary for implementation of the Project 25 standard.

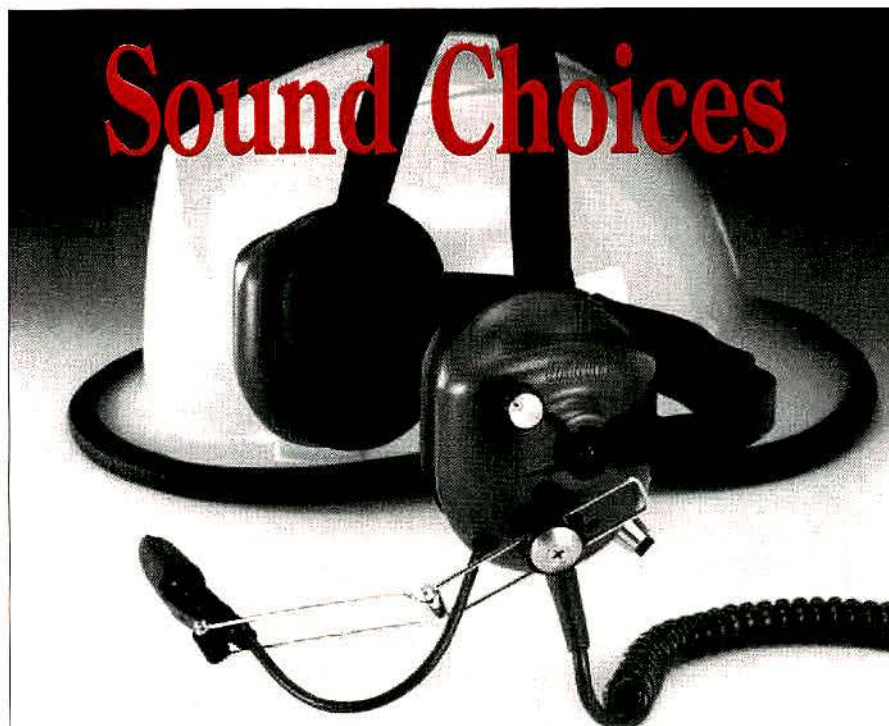
Circle (353) on Fast Fact Card

Book reviews the consumer electronics industry

The **Consumer Electronics Manufacturers Association's** annual review of the consumer electronics industry, *U.S. Consumer Electronics Industry Today* is a 120-page book. It includes highlights and updated statistics from 1996, along with a look ahead to future trends. The book is composed of chapters on video, audio, mobile electronics, multimedia, communication

and information, integrated home systems and accessories. The book also includes a detailed history of the industry, a list of CEMA members and contact information for related associations. All statistics in the book were compiled by CEMA's market research department and its market activity report program.

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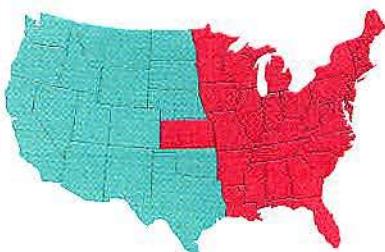
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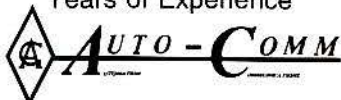
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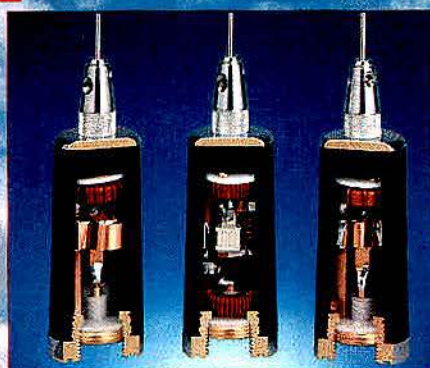
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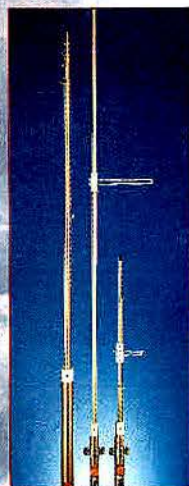
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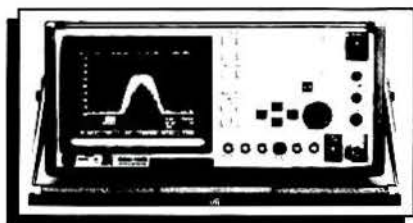
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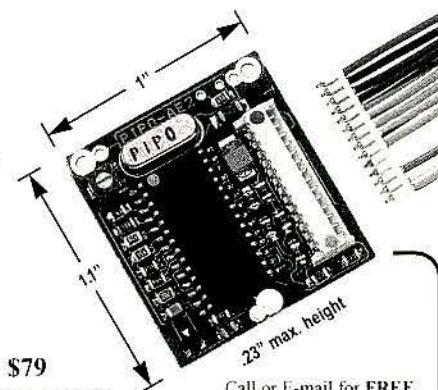
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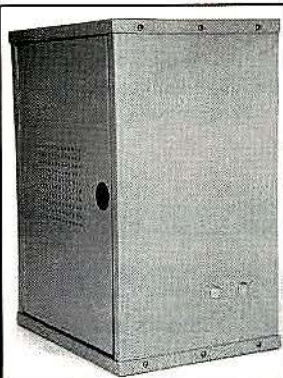
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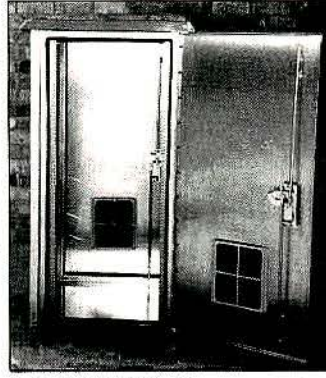
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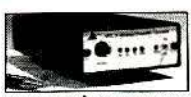
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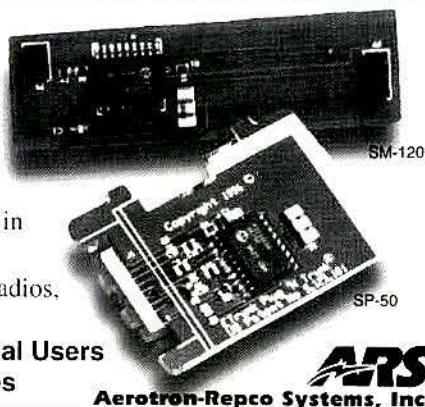
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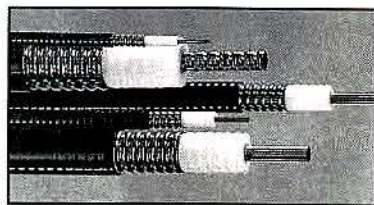
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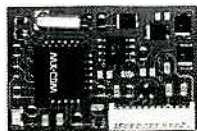
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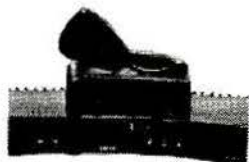
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| El Paso Comm. Systems | 91 | 124 | 915-533-5119 | TPL Communications Inc. | 42 | 52 | 213-256-3000 |
| General Communications | 90 | 120 | 800-356-3200 | Transcript International LTD | 3 | 5 | 800-894-2609 |
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| Huber & Suhner Inc. | 59 | 61 | 802-878-0555 | Trylon Mfg. Co. Ltd. | 70 | 42 | 519-669-5421 |
| Hutton Communications | 17 | 9 | 800-442-3811 | TX RX Systems Inc. | 23 | 22 | 716-549-4700 |
| Hutton Communications | 84 | 106 | 800-442-3811 | Vega, A Mark IV Co. | 1 | 4 | 818-442-0782 |
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| JFW Industries Inc. | 40 | 50 | 317-887-1340 | Wacom Products Inc. | 62 | 47 | 817-848-4435 |
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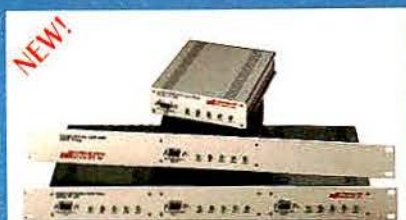
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